The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

VOL. VIII. PITTSBURGH, PA., MARCH, 1920. No. 3.

The Hump Method for Heat Treating Steel

New Method Utilizes Transformation Point Record to Indicate When Work Should Be Withdrawn From the Furnace—Description and Illustrations of Equipment Used.

A NEW method for the heat-treatment of steel has recently been introduced, which promises to revolutionize hardening room procedure and results. The purpose of heat-treating processes is to impart certain qualities of hardness, toughness, tensile strength, grain structure, etc., to the material, and this should be reliably accomplished without change in size or shape, without scaling or decarbonization, without waste of material by faulty treatment and with the least possible expense for labor and supervision. In all of these respects the new method known as the "hump method," exerts a favorable influence upon hardening room practice.

The hump method, as covered by U. S. Patent No. 1,188,128, utilizes the outward manifestation of changes in internal structure which takes place when steel is heated past the so-called critical or transformation point to indicate when the work should be withdrawn from the furnace. In using this method, the temperature of the furnace, and therefore of the work, is raised at a uniform rate until the transformation point of the steel is reached. At this time there will be a marked decrease in the rate of temperature rise. This change in the rate of rise is made plainly visible to the operator by an autographic recorder connected to a thermocouple placed close to or in contact with the work. The effect is clearly shown by a bend or hump in the curve as at C, Fig. 1.

This hump corresponds to a pause in temperature rise or decrease in rate of heating of the steel, which occurs in spite of the fact that heat is being transferred to the work during this interval as rapidly as before or after. It is explained by metallurgists as being due to the dissolving of cementite, or carbide of iron, in the pure iron, or ferrite, and to other chemical and physical changes, depending upon the compositio nof the steel. By microscopical and chemical means, it is known that the physical and chemical structure of steel after quenching is profoundly influenced by the relative time of quenching with respect to the time at which the arrest occurs. The hardness, strength, ductility and toughness are all definitely influenced.

As a guide in hardening, the temperature pause, or decalescence point, as it is called, is much more reliable than is the furnace temperature as indicated by a pyrometer. The arrest in temperature signaled by the hump or bend in the line drawn by the pyrometer pen shows that the internal changes so momentous as affecting the qualities of the finished steel, are actually taking place, and once the proper interval to be allowed after the hump before quenching has been determined, there is no uncertainty about the results of hardening.

If, on the other hand, the work be controlled with reference to temperature readings only, there are several possible sources of error, namely:

(a) The thermocouple may be at a temperature different from that of the work, due either to insufficient time having elapsed for the work to assume the furnace temperature or to inequalities in temperature between different parts of the furnace. Experiments which have been made with commutating recording pyrometers connected to read alternately upon two or more thermocouples in a single furnace show how surprising differences in temperature persist even after prolonged "soaking." To insure that the work shall actually reach the desired temperature within a reasonable time, the furnace is often held at a higher temperature, which is afterwards reduced. The "soaking" and possible overheating of the work may, and often do, result in injurious growth in grain size in the metal being treated

(b) In attempting to hold the furnace at a constant temperature, the temperature may fluctuate, and even though it may subsequently be reduced to the proper temperature, the work may nevertheless have been overheated and injured. In the hump method the quench is made as soon as the work is at the right distance above the critical point, and the work is given no opportunity to reach an excessive temperature.

(c) The temperature which is assumed as the critical temperature of the steel may not be correct. On the other hand, using the hump method, the time at which each lot of material passes through the critical point is definitely located.

The lead pot and the fused salt bath methods of heating work for hardening give greater assurance than does the ordinary furnace that the work shall reach a uniform temperature, but there still remain uncertainties as to the actual transformation temperature and as to accuracy of the temperature measurement, and growth in grain size due to too long immersion may occur. Lead or salt baths give no control whatever of the rate of heating. Hardening baths also have many practical disadvantages, such as expense, dirt, necessity of subsequently cleaning the work, space occupied, etc.

(d) The pyrometer used for measuring furnace temperature may be incorrect.

The user of the hump method need not concern himself about the absolute accuracy of his pyrometer, nor bother with independent transformation point determinations. It is not at all necessary that the temperature indicated by the thermocouple should be the correct temperature of the work, for so long as the recorder connected to the thermocouple shows clearly the pause in temperature rise, the moment at which transformation occurs is definitely known. Having learned by trial just how many minutes should elapse after the beginning or end of the transformation before the work is removed from the furnace, he is upon sure ground and can repeat results.

Uniform, standardized conditions and a control of the rate of heating the work are essential to the hump method of heat treatment. A small furnace for heat-treating tools, dies, etc., is shown in Fig. 2. The heating element consists of a vertical, cylindrical resistor, surrounded by insulating material in a sheet-iron jacket. The resistor rests upon a refractory block, which is supported by a cast-iron bottom plate. The heating chamber is closed at the top by a refractory cover, while a cast-iron top-plate confines the top loose insulating material, filling the space between resistor and jacket. An iron-constantin thermocouple of bare No. 8 gauge wire projects upward from the center of the bottom refractory block.

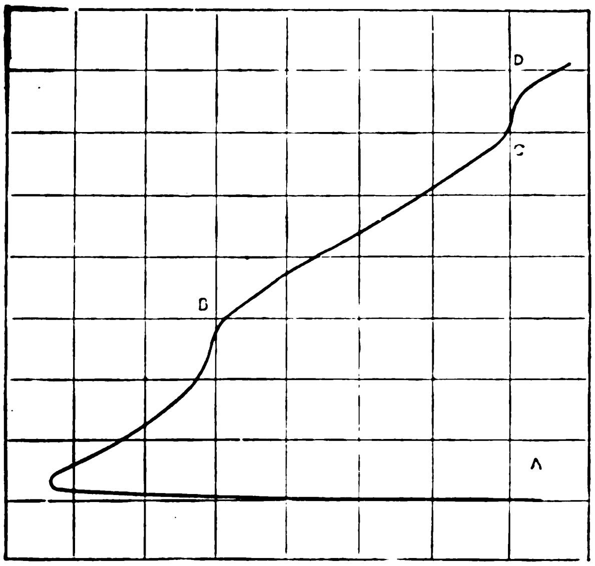

Fig. 1—Chart from a curve-drawing pyrometer showing hump C-D due to passing of steel through the transformation point.

By means of a small wire attached to a tool support on the top plate of the furnace, the work to be treated can be suspended in close proximity to, or touching, the end of the thermocouple. In production furnaces other methods of supporting the work are used. For example, in the furnace shown in Fig. 3, designed for heat-treatment of automobile transmission gears, the work is placed upon holders before insertion in the furnace. Covers placed on the furnace completely close in the heating chamber, preventing renewal of the atmosphere, and the work is thus protected against oxidation and scaling.

At the moment when the work is introduced into the furnace, the temperature of the latter is, say, 1,400 degrees F., but the heat storage capacity of the furnace walls being small compared with that of the charge, the temperatures of both thermocouple and furnace walls drop rapidly a few hundred degrees, the current through the heating element or resistor being shut off during this time. The result can be seen in the chart made by a curve-drawing pyrometer connected to a thormoucouple located in a furnace operated in the manner just described, as reproduced in Fig. 1. The temperature drops rapidly from 1,400 degrees F. at A to about 870 degrees F., and then rises slowly to B, where it is stationary, the thermocouple, furnace walls, and all parts, small and large, of the charge having reached approximately the same temperature. The switch is then closed, the input being so regulated that the temperature rises at the desired rate. The fact that the work and furnace start from the same temperature at B, far below the critical point, coupled with a proper arrangement of the heating element, with respect to the charge, insures that all parts of the work will go through the critical point at the same time. This is desirable in order to avoid stresses and distortion that would follow from unequal expansion or contraction if different parts of the work passed through the transformation point at different times.

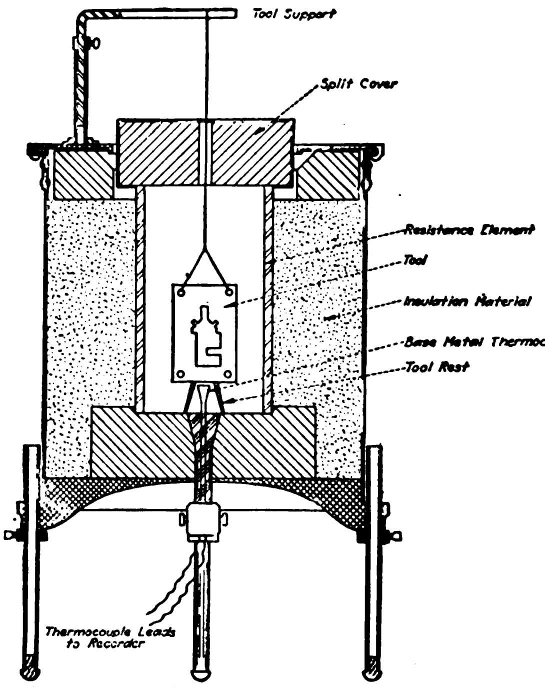

Fig. 2—Electric furnace used for heat treatment of tools, dies, etc., by the hump method.

The arrival of the work at the transformation point C causes an abrupt change in the rate of heating, due to the suddenly increased capacity of the steel to store heat, the temperature stops rising or proceeds much more slowly than before, although the rate of supply of heat energy has not been changed, however, once the transformation is completed, as at D, the temperature again rises rapidly. The pause is plainly shown by the hump in the curve.

Before quenching, it is necessary to heat the work for a certain time after this point, the time depending on the mass and shape of the steel, the quenching medium employed, and the qualities desired. The exact further heating to be allowed after the completion of the transformation point is learned by experience or trial, but once known, all uncertainty as to the result is practically eliminated.

In using the hump method, the metal is quenched without hesitation, as soon as the pen has gone the prescribed distance past the "hump" which indicates the transformation point. Errors due to inaccuracy of pyrometers, non-uniform temperature in the furnace failure of the work to reach the furnace temperature, or incorrect information regarding the transformation temperature, are avoided, and the steel is not injured by overheating or by holding it at a high temperature for too long a time. Each piece of work carried the same distance beyond the reference point C or D will show the same internal structure. This is true whether or not the temperature represented at the point C on the chart is correct, and whether or not it is the actual temperature of the steel at that moment. The important fact is that the chart tells the attendant when the steel is going through the transformation, from which he may know that quenching after a certain interval will secure the desired physical qualities. Furthermore, the chart remains as a record of just how each individual lot of steel was treated, and can be referred to in connection with properties developed in physical tests of that steel.

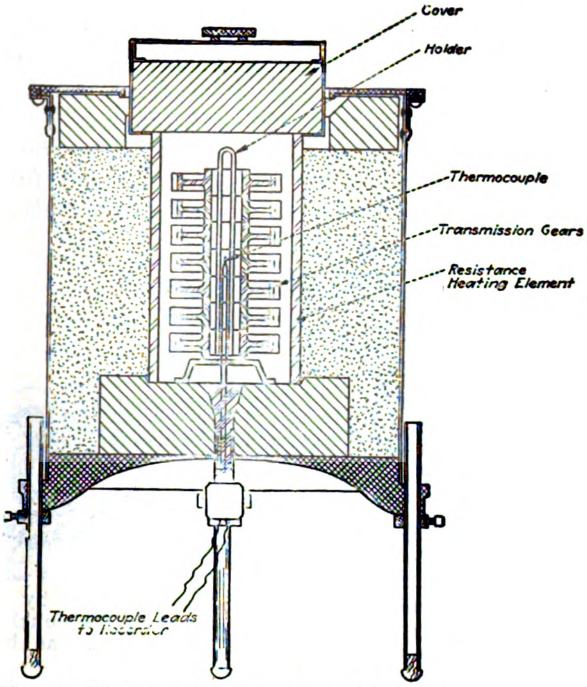

Fig. 3—Electric furnace used in the commercial production of automobile gears by the hump method.

It is found that the rate of temperature increase has a marked influence upon the properties exhibited by the steel after quenching. The resistance furnace is admirably adapted for controlling the rate of temperature rise, since the rate of energy input is easily regulated by reference to an ammeter supplied as part of the furnace equipment. The potentiometer pyrometer, Fig. 4, is likewise peculiarly suited for carrying out the hump method of heat treatment, as it is sensitive to small changes in thermocouple emf, and exhibits changes in rate of temperature rise upon a magnified scale. It is, in fact, the only form of pyrometer having these qualities in the desired degree.

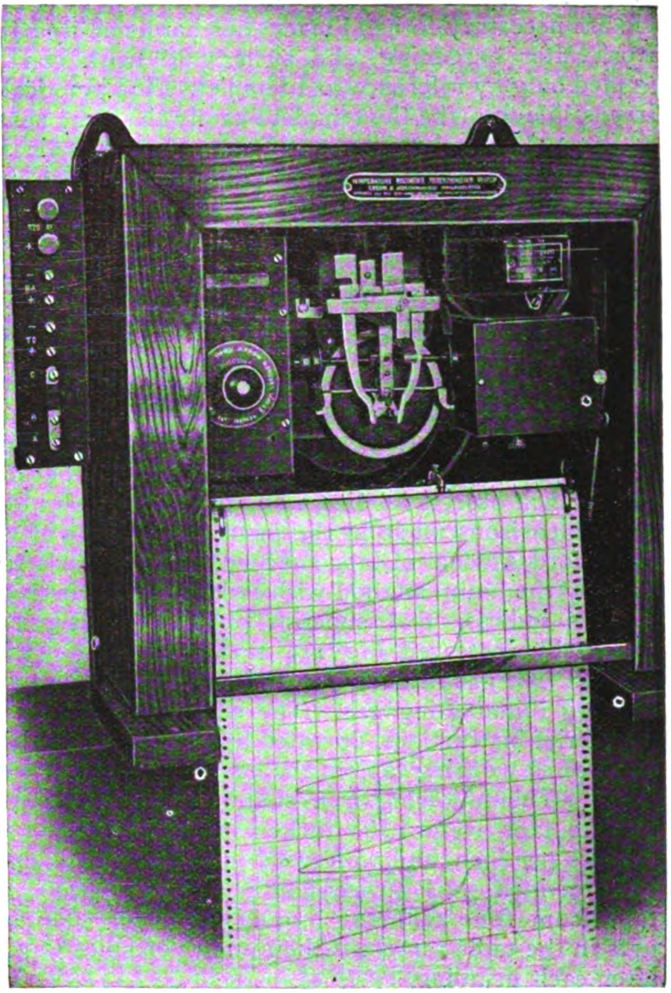

Fig. 4—Leeds & Northrup Curve-drawing Potentiometer used in connection with the hump method of heat treatment. The pen trace on the chart shows records of the heat treatment of successive lots of automobile transmission gears.

As an example of the use of the electric furnace in hardening tools, the manner in which punches and dies are produced in a shop where this method has been used exclusively for the past six years will be described. One of these punches and dies is shown in Fig. 5. The punch is first made in the ordinary way by machining and hand finishing. It is easy to secure accuracy in the making of a punch, as all measuring, gaging, etc., is done on the outside. The die is made to approximately the correct size, but slightly smaller. The punch, having been hardened and ground to exact dimensions, is then used as a broach to cut the die. It is forced into the die a short distance, raising a burr, which is removed by filing, the operation being repeated until the cut is finished. The die is then relieved, but no further work is done on the cutting edge. After hardening the die by the hump method, the size and shape are found to be so exact with respect to the punch, that subsequent work, as stoning or grinding, is not required.

Dies which have been broached by the punch and then hardened by the hump method, are superior, for purposes where close correspondence of punch and die are necessary to hand-made dies hardened by hand work after hardening, and such hand work can be guided only by reference to a templet. It is practically impossible to make the templet exactly the same shape as the punch, and it is also difficult to make a die exactly the same shape and size as the punch, as any hand work is necessarily more or less irregular.

The fact that dies hardened by the hump method fit exactly with the punches by which they are broached, shows that there has been no volume change or distortion during the process of hardening. It has been found, however, that the previous history of the material, the rate of heating and the interval which is allowed to elapse between the transformation point and the quenching point has certain relations to volume changes which are of great importance in the hardening of such objects as dies, milling cutters, gears, etc.

Comparisons made in the instrument shops of the Frankford Arsenal of taps hardened in an electric furnace by the hump method with taps hardened in a gas furnace indicate that superior physical qualities, as shown by increased life, are obtained by the hump method. The gas furnace was of the partial muffle type, burning illuminating gas. The electric furnace was, after brief instructions, operated by the same man who had been hardening taps in the gas furnace for several years. The following is a summary of the results: The taps were 1.504 inches in diameter, had 12 threads per inch, and were used in tapping fuse holds in three-inch steel projectiles. Tests were made on taps from four different brands of steel. The figures in the table represent the number of holes tapped after each grinding.

Brand A

	New	First regrind	Second regrind	Third regrind	Total	Increase in life
Average (7) gas treated........	29	204	86	65	384	
Average (2) electric treated.....	100	270	33	103	506	32%
Brand B						
Average (7) gas treated........	84	151	25	36	296	
Average (2) electric treated....	7	384	26	20	437	48%
Brand C						
Average (9) gas treated........	94	210	207	9	520	
Average (8) electric treated....	414	232	129	8	782	50%
Brand D						
Average (7) gas treated........	131	243	340	71	792	
Average (2) electric treated....	520	107	350	10	987	25%

With each brand of steel, therefore, taps hardened in the electric furnace showed a greatly increased life over those hardened in the gas furnace.

Except with brand B, the average is very marked before the first regrind. The fact that these taps averaged 384 holes after the first regrind indicates that the fault is not in the hardening, but in some unavoidable features in the grinding, or in the use of the taps. The outer case of the taps should be the hardest, and if the tap is held to shape in hardening, more of its hard surface remains for use. This would probably be the case in the electric furnace and might account for the greater life before the first regrind. Then, again, there is more decarbonization in the gas furnace, and this would cause the surface to be composed of low carbon steel, which would not be good for cutting purposes. The life of a tap would naturally be expected to decrease gradually as in brand C (electric treated). In the electric furnace the work is heated in a neutral atmosphere, and emerges practically as clean after hardening as before it was placed in the furnace, saving considerable in time and money for finishing.

Production operations are greatly simplified by the use of electric heat-treating furnaces with the hump method. As an example refer to Fig. 6. Formerly in this plant automobile transmission gears were heated for hardening in lead pots located in the basement beneath the machine shop. After the gears had been machined, they were removed on trucks to an elevator, lowered to the heat-treating room, an uncomfortable place because of heat and fumes, and wheeled to the lead pots. The gears were placed in the lead pots in batches, and when they had come up to temperature, were lifted out one at a time, and dropped into the oil quenching bath. The time of heating in the lead pots was thus not the same for all pieces, and the temperature also varied with the location in the pot, possibly resulting in non-uniform hardness and grain structure. The gears were also sometimes injured by dropping upon one another in the quenching tank. The drawing was done in gas furnaces, followed by an oil quench. Upon their return to the machine shop, the gears were wire-brushed to remove adhering lead.

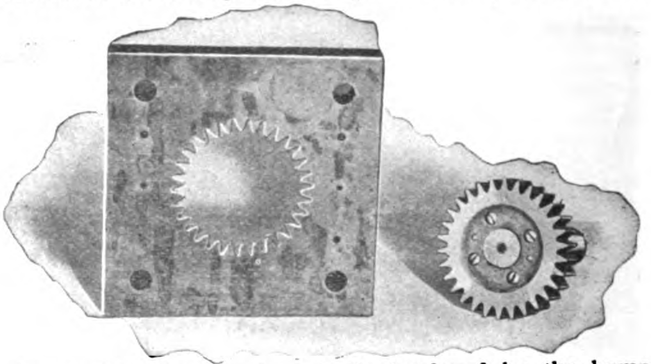

Fig. 5—Blanking punch and die hardened by the hump method. The die was broached by the punch and then hardened. Although no hand-work has been done upon it, it still fits the die perfectly.

The electric furnace equipment replacing the lead pots and gas furnace is located in the machine shop itself. There are six electric hardening furnaces located on two sides about a quenching tank, with three electric annealing furnaces on the remaining side, also a drain grid and the cleansing bath between the quenching tank and the annealing furnaces. The tops of all furnaces and tanks are flush with an elevated paltform. The work is brought on trucks

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to the edge of the platform, where a boy arranges the gears upon holders, which are easily picked up by the operator, and upon which the gears remain until they have passed in turn through hardening furnace, quenching tank, cleansing bath and drawing furnace. Corresponding to each hardening furnace, there is a curve-drawing recorder, and for each drawing furnace an automatic temperature recording controller, all mounted upon a wall near by, where also are the furnace rheostats. An assistant foreman on duty at this point directs the operations according to the indications of the curve-drawing recorders connected to the hardening furnaces.

The amount of electrical energy consumed by the electric furnace is comparatively little, due to the very efficient insulation. There is no loss of heat in waste gases, as with combusition furnaces, leaving to be supplied only the heat imparted to the work. The higher cost of electrical energy is more than repaid by the saving in necessary apparatus, such as pumps, blowers, burners, etc., and the labor costs, as the electric furnace can be located in the machine shop in the direct line of manufacture, thus saving the double handling of the work which is necessary where the latter must be taken from the machine shop to a hardening room and then back again.

The use of the hump method in regular manufacturing results in a higher grade, a more uniform output, and simplifies handling and cleaning to such an extent as to render the cost of electrical energy of minor importance. Dependable results and large volume of output are obtained with regularity and certainty, and without requiring a large number of skilled men.

Where electric furnaces are used in the tool room, the tool-maker can be closely in contact with the hardener, so that methods of operation in tool making, which often increases the difficulties of the hardener, can be avoided, while through the use of the hump method it is sometimes possible to simplify the work of the tool maker as related in connection with die making.

The hump method of heat treatment is controlled by Leeds & Northrup Co., of Philadelphia, which company also manufactures the electric furnaces and curve-drawing pyrometers used in carrying out the process. Hump method equipments for hardening tools and dies have been installed by such concerns as the Ingersoll-Rand Co., the Miller Lock Co., etc., while equipments for large-scale commercial production are used by the manufacturers of the Packard, Hudson, Dort and Nash motor cars, by the Detroit Gear and Machine, and Brown Lipe Gear Companies, and by other well-known concerns in the automobile field.

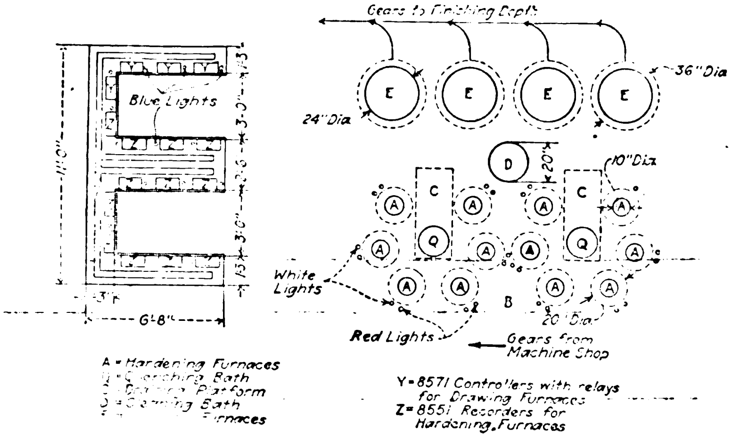

Fig. 6—Layout of hump method heat treatment equipment in the machine shop of a large producer of automobile gears.

Co-efficient of Expansion of Alloy Steels

Importance of Correct Conception of Co-efficient of Expansion. Table Shows Mark, Analysis, Tensile Properties, Hardness, Izod Figures and Co-efficient of Expansion for Two Ranges of Heating.

By **JOHN A. MATHEWS,**
President, Halcomb Steel Company.

DURING the prosecution of the aircraft-production program in 1917 and 1918, the writer visited many plants engaged in the manufacture of motors, planes and parts, in carrying out his duties as chaiman of the Committee on Aircraft-engine Forgings. On several occasions, when the question of expansion was discussed, it was noted that there was confusion in the use of the terms: the true coefficient of expansion, a physical constant, and distortion in hardening. One engineer, referring to a steel shown in the accompanying table, stated that he could not consider it for crankshafts because of its excessive coefficient of expansion, while another steel, also listed in the table, was said to be especially good because it had no coefficient of expansion, since it came out of the oil bath perfectly straight. Many years ago one of our employes designed a new oil furnace; when asked what became of the products of combustion, he replied: "There ain't any, we burn them all up."

While the coefficient of expansion is not without its effect in volume changes in hardened steel, it is not a determining factor in the matter of distortion and going out of shape. Irregular heating, uneven furnace bottoms, and carelessness in withdrawing the part from the furnace, as well as the manner in which the part enters the quenching bath are of greater moment. Generally speaking, also, steels of relatively low hardening temperature will distort less than those

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Paper presented before the February meeting of the American Institute of Mining and Metallurgical Engineers.

requiring higher hardening heats. The coefficient of expansion must be considered in engineering design most frequenty when different metals or alloys are used in the same construction. For example the difference of expansion between a steel crankshaft and an aluminum crank-case might be of real importance and a steel with no coefficient of expansion would be much less desirable than one with the normal coefficient.

About 15 years ago, the writer made many determinations of the coefficient of expansion at low temperature ranges, usually between 20 degrees and 100 degrees C. Among the materials tested were: Pure forged electrolytic iron, 11.73 parts per million for 1 degree C.; cast aluminum (99.93 per cent. Al.), 23.86; Monel metal, 13.75; nickel steel (30 per cent Ni.), 13.38; soft steel, 11.09; commercial nickel, 12.42. These figures illustrate a general defect noticeable in much of the published data, namely. complete analyses and conditions of heat treatment are frequently lacking. For example, the following values are taken from tables of physical constants: Soft iron, 12.10; wrought iron, 11.40; steel, annealed, 10.95; steel, 13.22; nickel, 12.79; cast brass, 17.22; tempered steel, 12.40.

Most of these materials may represent a wide variety of analyses and a wide varity of physical conditions and a comparison of various tables from different sources would lead one to suspect that there was likely to be some variation in the constants of nature. Few laboratories are equipped to make these tests and, at least until very recently, there has not been available any commercial form of dilatometer that could be used by the average laboratory worker. It would not be necessary for every laboratory to make these determinations if the full information were available in connection with the determinations that have already been made by many able investigators.

Through the coöperation and assistance of Maj. Healset and Capt. H. F. Wood, of the Detroit Branch of the Aircraft Production Department, our committee was assisted in securing various types of alloy steels used for crankshafts; and in connection with them we have the analyses and tensile properties, also the hardness and shock-test values in several cases.

TABLE 1

Mark	Analysis									Tensile			
	Carbon	Silicon	Manganese	Phosphorus	Sulfur	Chromium	Vanadium	Nickel	Molybdenum	Elastic Limit, Lb. per Sq. In.	Ultimate Tensile Strength, Lb. per Sq. In.	Elongation, Per Cent., in 2 In.	Reduced Area, Per Cent.
WG12085...	0.34	0.10	0.64	0.012	0.023	0.76		3.43		122,500	142,750	17.9	57.0
Ford.......	0.30	0.11	0.66	0.025	0.005	0.86		3.05	0.53	135,700	149,000	19.0	63.0
PF16990....	0.50	0.15	0.64	0.015	0.031	0.88		1.90		124,300	140,600	20.0	56.4
X..........	0.32	0.23	0.53	0.013	0.015	1.37		3.53		145,000	154,000	19.5	60.95
6555.......	0.35		0.65	0.008	0.045	0.80		3.14		125,500	135,250	18.5	56.2
15772......	0.43		0.78	0.015	0.027	0.75		1.87		129,650	147,400	18.5	57.7
16404......	0.43	0.18	0.81	0.031	0.032	0.88	0.07	2.55		140,000	155,500	17.5	50.63
257........	0.40	0.14	0.76	0.006	0.012	1.20	0.17			157,500	175,500	16.0	50.9
1048.......	0.34	0.17	0.72	0.009	0.010	0.96	0.17			119,000	135,000	20.0	59.95
1156.......	0.44	2.07	0.81	0.012	0.010					117,500	148,000	22.5	49.55
1223.......	0.40	0.57	0.78	0.011	0.015	0.78				90,000	118,500	20.5	58.9

Mark	Hardness		Impact Test	Coefficient of Expansion, Parts per Million per 1° C.		Source and Treatment
	Brinell	Shore	Izod	Range 25° to 100° C. 77° to 212° F.	Range 25° to 270° C. 77° to 518° F.	
WG12085..	311	51	56	11.37	12.49	Liberty shaft from Lincoln.
Ford......	302	43	51	11.67	12.57	Liberty shaft from Ford.
PF16990...	302	50	49	11.72	12.70	Liberty shaft from Packard.
X.........	325			11.83	12.78	Quenched 1525° F. (830° C.) oil; drawn 1050° F. (570° C.).
6555.......				11.73	12.79	Liberty shaft, source unknown.
15772......	302			12.00	12.87	Liberty shaft, source unknown.
16404......	323			11.65	12.89	Rolls-Royce shaft.
257........	370			11.60	13.04	Quenched 1700° F. (930° C.) oil; drawn 1200° F. (650° C.).
1048.......	282			11.76	13.10	Quenched 1700° F. (930° C.) oil; drawn 1150° F. (620° C.).
1156.......	318			12.52	13.51	Quenched 1700° F. (930° C.) oil; drawn 1100° F. (590° C.).
1223.......	237			12.76	13.83	Quenched 1525° F. (930° C.) oil; drawn 1100° F. (590° C.).

The writer has supplemented this list with other types of alloy steels frequently used for axles, shafts, etc.; all of this material has been tested in a heat-treated condition, which has produced elastic properties between 100,000 and 150,000 lb. per sq. in. yield point. The Bureau of Standards coöperated with the committee and made the actual tests of coefficient of expansion, which is a sufficient guarantee of the accuracy of the figures presented. We hope the complete data presented may prove of value to engineers and that future authors, in presenting data on the same subject, may follow the example set. The accompanying table shows mark, analyses tensile properties, hardness, Izod figures and the coefficient of expansion for two ranges of heating, viz., 25 to 100 degrees C. (77 to

212 degrees F.), and 25 to 270 degrees C. (77 to 518 F.), the steels being arranged in the order of increasing coefficients for the wider range of heating.

Where exact heat treatment is not given, we feel reasonably certain that the crankshafts were hardened from a temperature of about 1,550 degrees F. (840 degrees C.) and quenched in water until black, after which they were immediately put into the drawing furnace and the temper drawn to about 1,050 degrees F. (570 degrees C.). In a few cases it is possible that the original quenching was done in oil rather than in water.

It will be noted that the maximum variation between the highest and the lowest coefficient of this widely differing group of steels is only 1.34 parts per million for 1 degree C. Practically considered, there would be considerable difference between these steels as to their actual behavior on quenching in regard to the distortion which would take place, but this small difference in coefficient of expansion can hardly be considered as the cause of these differences. On the other hand, a tool-steel product introduced to the American trade by the writer's company many years before his connection with the company, is free from distortion in hardening and in volume change after hardening and tempering; it displays a normal expansion upon heating, not differing in any way from that of plain carbon tool steel. It shows a greatly increasing rate of dilation upon heating up to Ac_1, but then undergoes the usual marked contraction until decalescence is complete, followed by a new dilation at a greater rate than that below Ac_1, which agrees perfectly with Le Chatelier's observations upon the behavior of carbon steels referred to previously by the writer. The fact that this product holds its shape more nearly than any other tool-steel product and undergoes almost no volume change when properly hardened, peculiarly adapts it to a wide variety of uses in the toolroom and shop. That it met a pressing need is further shown by the fact that a steel of this type is now made by nearly every manufacturer of tool steel. As the writer was not connected with the original development of this product he may be pardoned if he expresses an opinion that its properties are of interest second only in importance to the invention of high-speed steel.

The low-carbon chromium-nickel steels undergo normal expansion on heating, yet in one instance fairly large and intricate gears for airplane use were made from this type of steel. They were so well handled, in the hardening and subsequent treatment, that they showed no warpage or distortion and required no straightening or grinding after the heat treatment. This result was due to the skill of the operator, as the gears were not hardened in dies or with a gear-hardening machine. As they were for airplane use, they were very light and of a construction very apt to cause trouble unless the greatest care was exercised in the treatment. This again illustrates the fact that the coefficient of expansion, in itself, is not a primary cause of distortion in heat treatment, although, in general, hardening from a temperature just about that at which the maximum contraction takes place at decalescence would tend to improve the final results of hardening so far as distortion is concerned; this practice is now in use in some progressive plants where the end of decalescence is directly determined from pieces in the furnace rather than by relying upon the reading of the pyrometer located at a more or less remote spot in the furnace.

Blast Furnace and Hot Stove Refractories

Recent Developments in Refractories With Special Reference to Methods of Study Applied to Blast Furnace Practice—Factors Controlling the Quality of Firebrick.

By **RAYMOND M. HOWE.**

SOME time ago, a prominent engineer asked a representative of the firebrick industry to prepare a comprehensive paper on blast furnace refractories. It was to have been the purpose of this paper to gather practical experiences from widely different sources, in the hope of determining what kind or kinds of firebrick were best adapted for certain uses. This engineer sent questionnaires to the large consumers of blast furnace linings and stovebrick and received very detailed replies as to their experiences. These replies are conflicting, but, having been turned over to the writer, form the basis of this attempt to meet the request. Because of the impossibility of making final recommendations at this time, a few of the more interesting and commonly known methods of studying refractories are also discussed, as well as the more recent developments in this field.

The first reply to the questionnaire stated that good service was being secured from the linings. This satisfactory condition was attributed to the use of a very good distributor. The writer believed that manufacturers try to and do produce a good product and that the proper handling of equipment is of the utmost importance, if good results are to be secured.

The author who is Senior Fellow on Industrial Fellowship of the Refractories Manufacturers Association, Mellon Institute of Industrial Research, read this paper before the last Chicago meeting of the American Institute of Mining and Metallurgical Engineers.

The type of bricks used was not mentioned. The second reply stated that good life was secured from the furnace linings, but that the writer had had soft-fired stovebrick crumble and, for that reason, preferred a hard-fired product for use in this position. The type of bricks used was not mentioned. The third reply stated that firebrick had crumbled from the mantle up; the cause was not known. The fourth reply stated that the stove linings were satisfactory. Hand-made furnace linings failed after four years' service so a steam-pressed lining was installed which was still good after four years of service. Consequently, a second steam-pressed lining was installed but this disintegrated at the top after the furnace had been in blast seven months. The firebrick manufacturer attributed this failure to the expansion of iron blocks that had been installed at the stock line to prevent erosion.

The fifth reply stated that the present "hard-burned" hand-made furnace lining had worn away very uniformly to the depth of only 5 inches after 1,042,000 tons of pig had been produced. It strongly advocated the use of only the best clay in laying up linings. No stove trouble had been encountered. The sixth reply stated that the writer had secured 16 and 17 years of service from two sets of stoves. At the end of 17 years, one was torn down because of the poor condition of the shell but the checker work was still good. He was forced to reline the combustion chamber from time to time, but hoped to avoid this by washing the gas. He preferred steam-pressed linings to the hand-made, "as the joints are smaller and scaffolds do not get a hold as easily as on the more open joints."

The seventh reply was more comprehensive and instructive. This writer stated that a number of operating and construction factors beside the physical and chemical nature of the linings themselves affect the life and performance of furnace linings. The most important of these are: Furnace lines, volume of air blown, diameter and lengths of tuyeres, stock line protection, arrangement of gas outlets at furnace top, stock distribution, chemical and physical nature of raw materials, continuity of operation, judgment, knowledge and care by furnace operators. The following data were also given:

Furnace	Blast No.	Days in Blast	Days Operated	Tonnage	Kind of Brick in Lining
2	1	790	744	282 594	Hand-made
2	2	870	870	336,641	Hand-made
2	3	972	972	330,900	Hand-made
2	4	1,607	1,577	628,979	Hand-made
3	1	779	707	252,107	Hand-made
3	2	950	950	365,626	Hand-made
3	3	978	978	351,085	Hand-made
3	4	1,251	1,235	529,316	Steam pressed
4	1	918	904	401,918	Hand-made
4	2	1,664	1,657	823,238	Hand-made

He said, "The Brown top on No. 3 furnace during the first three blasts had the original Brown elliptic distributing spout, which had the effect of constantly pitching the stick, so that it was crowded toward the side of the furnace opposite the skip. At the beginning of the fourth blast, the spout was changed to one of V shape, which prevented pitching and effected a wonderful improvement in distribution." He never had brick made to specification but desired a well-burned brick, as pure as possible, made from the proper grinds and mixes to give the necessary physical strength He prefers a hand-made stove brick to the steam-pressed product the latter gives up the heart more rapidly His preference is due to the fact that his one trial of steam-pressed bricks involved a brick that was too dense, so that spalling occurred.

The eighth reply stated that the user had used the hand-made and the steam-pressed products of one company, but favored the hand-made, although he had never had any blast furnace lining failures other than the usual erosion. The stove linings had given satisfaction. Tests that had been made on firebrick were also submitted; these are given in Table 1. The ninth reply said the distribution of the stock is the factor that controls the life of a furnace lining, stating "had the same success been achieved toward better blast-furnace tops and proper lines, as has been reached by the refractory brick manufacturers, there would be less said about poor brick "He stated that his company had increased the tonnage secured from three furnaces by changing lines, but were still having trouble with the linings of the fourth, due to no fault of the refractories.

These nine replies, which represented the opinions of those who used enormous quantities of blast-furnace linings and stove brick, were very encouraigng to the manufacturers of refractory materials, who had felt at times that perhaps that industry was not meeting the ever-increasing demands being made upon it as higher temperatures are employed. It is interesting to note that four companies secured good service from their furnace linings but gave no reason; one company attributed its success to the distributor being used; another had figures to show how the tonnage secured from each of three furnaces had been increased over 100 per cent. by bettering furnace lines and control. One reply was less complete but was of the same context. The failures are difficult to explain, for the crumbling of a top could have been due to one of three causes, the last of which is improbable because of the conditions under which the furnace operates: The action of furnace gases or carbon; the crushing of the bricks; or the loss of bond after repeated heating and cooling. The influence of furnace gases was recently shown very forcibly when iron was removed

Furnace	Blast No.	Hearth Ft.	Hearth In.	Bosh Ft.	Bosh In.	Bosh Angle Deg.	Bosh Angle Min.	Stock Line Ft.	Stock Line In.	Bell Ft.	Bell In.	Number of Tuyeres	Kind of top
2	1	12	6	19	6	72	0	13	6	9	0	12	Handfill
2	2	12	6	20	0	71	20	13	6	9	0	12	Handfill
2	3	12	6	19	6	76	0	13	6	9	0	12	Handfill
2	4	13	6	20	0	74	51	13	6	10	0	12	Handfill
3	1	13	3	20	6	73	18	14	3	10	0	12	Brown
3	2	13	3	20	6	73	18	14	3	10	0	12	Brown
3	3	13	3	20	6	75	0	14	3	10	0	12	Brown
3	4	14	6	21	0	75	25	15	0	10	0	12	Brown
4	1	15	0	22	0	75	0	16	0	11	0	12	Neeland
4	2	16	0	22	0	76	30	16	0	11	9	12	Neeland

Table 1—Properties of Firebrick.

	Kind of brick	Chemical Analysis							Physical Tests					
		Loss on ignition per cent	SiO_2, per cent	Fe_2O_3, per cent	Al_2O_3, per cent	CaO, per cent	MgO, per cent	K_2O, per cent	Crushing strength lb. per Sq. In. side	Specific gravity True	Specific gravity App.	Porosity per cent by volume	Abrasion 10 Lb. for 10 Min. applied to end Wt., Gr.	Abrasion Cu. In.
1	Top	0.00	52.84	3.95	41.34	0.12	0.21	1.54	....	2.40	2.06	14.08	31	0.000
2	Top	0.07	54.44	2.53	40.01	0.18	0.53	2.24	5098	2.34	2.03	12.93	62	0.120
3	Inwall	0.08	50.20	3.58	43.14	0.25	0.38	2.37	3910	2.28	2.00	12.29	38	0.075
4	H. & B.	0.07	50.57	3.87	42.73	0.25	0.34	2.17	5153	2.33	1.98	14.92	90	0.180
5	Inwall	0.00	52.36	3.25	42.65	0.09	0.19	1.46	3500	2.33	2.00	14.09	18	0.036
6	H. & B.	0.02	59.83	3.34	34.82	0.15	0.34	1.50	3468	2.38	2.07	12.92	252	0.480
7	Top	0.02	64.01	3.08	30.61	0.12	0.36	1.80	3906	2.32	2.01	13.32	25	0.049
8	Inwall	0.04	53.28	3.51	41.00	0.12	0.28	1.77	3750	2.33	2.04	12.71	185	0.360
9	H. & B.	0.02	53.34	3.51	41.18	0.12	0.26	1.57	2711	2.39	1.97	17.54	74	0.150
10	Top	0.00	57.62	3.69	37.62	0.15	0.16	0.76	5360	2.48	2.12	14.57	19	0.035
11	Inwall	0.01	56.07	3.32	39.00	0.12	0.18	1.30	5248	2.43	2.10	13.30	38	0.072
12	H. & B.	0.15	53.19	3.34	40.91	0.56	0.26	1.59	3923	2.52	2.01	19.97	73	0.140
13	H. & B	0.14	49.66	2.66	45.66	0.31	0.47	1.10	5110	2.46	2.11	13.91	518	0.97
14	H. & B.	0.21	56.30	3.75	37.21	0.37	0.35	1.81	4230	2.48	2.07	16.42	265	0.57

	Furnace Tests					Remarks		
	Average Temp. Deg. F.	Time, Hr.	Maximum Temp., Deg. F.	Expansion in per linear feet	Average permanent elongation per 9 in.	Surface fusion	Cracking	Fitting due to iron oxide
1	2960	4	3011	0.052	0.007	Medium	Very slight	Slight
2	3016	2½	3157	0.042	0.021	Slight	Very slight	
3	2900	4	3011	0.042	0.000	Slight	None	
4	2925	3	2983	0.042	0.042	None	None	Very slight
5	....	...	3000	0.075	....	Very slight	None	Slight
6	....	...	3000	0.064	....		None	
7	....	...	3000	0.084	....	Medium	None	Slight
8	....	...	3000	0.073	....	Medium	Slight	Slight
9	....	...	3000	0.064	....	Slight	Few and small	None
10	....	...	2905	0.096	....	Slight	Many small cracks	Badly pitted
11	....	...	3000	0.064	....	Very slight	None	Very slight
12	2925	3	2983	0.083	0.017	None	None	Slight
13	....	...	2905	0.136	....	Very slight	None	Very little
14	2983	3	3045	0.034	0.070	Slight	Very little	None

from optical-glass pots by chlorine or certain of its compounds. These pots lost all of their bond and fell into pieces. The ninth company secured such varying results from different bricks that it would be useless to attempt any explanation.

The service secured from stove brick appeared to be satisfactory in but two cases: one where the handmade brick were supposedly underfired and the other where the steam pressed brick were too dense. For the time being these explanations will be accepted.

The writer then visited different plants and learned other facts concerning failures and successes, all of which tend to show that the opinions of operators as well as manufacturers vary. In one case, a record furnace lining had been installed with no little concern, because it was so exceptionally hard-burned. As the lining was needlessly repaired, for the first time, after 1,042,000 tons of pig-iron had been produced, this leads one to believe that manufacturers should have no future trouble in disposing of extremely well-burned linings at that plant.

The stove service at the same plant was extremely good, and was attributed to the method of burning gas. Sufficient air was introduced to burn all the gas in the lower combustion chamber, while other operators allow the gas to burn in the upper combustion chamber and checkers. By following the latter practice, the dust separated out in the relatively cool zone at the bottom of the chamber and, not being fused, was easily removed. Here are two distinct practices. In their adoption it is necessary to consider whether the removal of the dust as dust, or longer service in the top courses of the stoves, is more desirable, for both conditions can hardly exist. At another plant, spalling constantly occurred. The brick proved to be a high-grade soft-clay product. The writer believes that the introduction of grog or flint clay into such bricks, when used in the combustion chamber and the top courses of checkers, would decrease the spalling. The following figures show the effect of the addition of small amounts of flint clay to plastic, the same kind of plastic clay and flint clay being used in each brick.

Experimental Data Showing Relative Resistance to Spalling†

100% Plastic Clay	90% Plastic Clay 10% Flint	80% Plastic Clay 20% Flint	70% Plastic Clay 30% Flint	60% Plastic Clay 40% Flint
3	4	3‡	6	22

†Relative resistance to spalling. ‡Erratic result.

At another plant furnaces were operating which had given the following tonnages: 727,330; 467,385; 714,114; 937,359; 391,660; 506,403; 669,740; 609,300. The superintendent attributed his success to the fact that he used cooling plates so freely that he was often criticized. By so doing he secured uniform wear at the bosh rather than the uneven wear resulting from alternate hot and cold spots.

Four cases of brick disintegration were mentioned at different plants. In one case the failure occured about 30 years ago in one of the old-type furnaces

In the second case, trouble began to occur in a very short time with the furnace using a high-barium high-sulphur ore, and complete failure resulted in a month. In a third case, a furnace was blown out and appeared to be in good condition; it developed, however, upon following a crack, that the inner 5 in. (12.7cm.) of lining were good, but that the back portions could be crumbled in the hand. In the fourth case the 13½ in (34cm.) brick, upon removal, were found to be split into from four to eight sections. This case is entirely different from the others, for those bricks crumbled into a thousand pieces, while these cracked into several pieces, each of which was strong. At another plant, extreme variations were noticed in a lining that was being installed, for the large blocks varied as much as 1 in. (2.5 cm.) in length and were warped in many cases. Two operators who had experience with such blocks thought that unless the blocks could be made with more uniformity they would revert to the smaller brick for furnace bottoms, although theoretically the larger blocks—because of the fewer joints—are better.

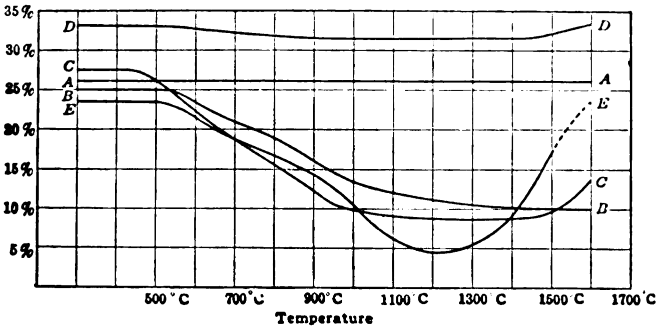


Fig. 1—Porosity of ground fireclay pieces when burned at different temperatures. A, open-burning flint clay; B, dense-burning flint clay; C, high-grade dense-burning plastic clay; D, high-grade open-burning plastic clay; E, low-grade dense-burning plastic clay.

Judging by the success of one plant, which more than doubled its tonnage from each lining, requiring less than twice the time to secure such tonnage, it appears as if there is a reason, other than the linings, why erratic results are secured in other places. This increased production was also one of gradual development, which excludes the element of chance. However, in order to secure more uniform results, it is essential that the furnace operator have uniform materials with which to begin. Having such, it is more possible to begin real constructive work. It is not the purpose of this paper to tell the steel manufacturers their mistakes or how to control their furnace practice, so it will be restricted to showing what the refractories manufacturers are doing to improve their product and make it as uniform as possible. By following such methods, on both sides, it is quite possible that answers from a questionnaire circulated 10 years from now would be free from contradictory statements and might give sufficient information to make it possible to explain successes and failures in this field.

The manufacturers of firebrick have shown their desire to produce better products from the available raw materials through the action of the Refractories Manufacturers' Association. This association is spending annually a considerable sum of money at the Mellon Institute of Industrial Research in supporting a staff of ceramic engineers and chemists, which has increased in number from one to five in less than two years. All of these men devote their full time to the study and improvement of refractory products. In addition, this association has coöperated with the Gas Institute for several years in trying to meet the demands of its members. It has also collaborated with the Bureau of Standards, the Bureau of Mines, and the American Society for Testing Materials in the development of such tests as will determine the most desirable products for their different uses.

Factors Controlling the Quality of Firebrick

The more important factors that influence the quality of a firebrick may be conveniently divided into seven groups. The clay is mined by underground or surface methods and is given a preliminary sorting at the mine or quarry. It is then transported to the plant, where it is again sorted as the larger pieces are crushed. After crushing to such size as may be handled by the grinding machinery, the clays are either ground separately and then mixed, or they are mixed and then ground. Both the dry and wet grinding practices are followed. Water is added during the grinding and mixing, the amount depending on the process of manufacturer. Then the shaping process folows in which the mix is worked by hand, in a dry press, through a die by different sources of pressure, or in a soft mud machine. After being shaped, the "green" ware is dried in tunnel driers or on hot floors until it is ready to be set in the kiln, burned, sorted and shipped. The seven steps in the manufacture of firebrick that may affect its quality or appearance, and which are being studied by different firms, are as follows: Mining and sorting of clay, grinding, proportioning, tempering, shaping, drying, burning.

Mining and Sorting of Clay

In order to mine and sort clays on a scientific basis, it is necessary to study each vein from the top to the bottom. This is particularly true of plastic clay, which sometimes shows variations in its different layers; yet when these are known they may be located by their color and structure. Accordingly, the practice of sampling clay is gradually increasing, samples being either taken from the operation from day to day or from drill cores obtained years before the clay is used. As a result of such studies, the refractoriness of some brands has been increased by 100° F., while in other cases clay that was not being mined, because of a peculiar color or structure, has proved to be superior to the run-of-mine product. These statements are not meant to imply that all plastic clays vary or that all plastic clays are carefully picked; some plastic clays are remarkably uniform and hence offer no problem, in others, a poor spot may occur in the center of the vein and cannot be entirely removed. Under such conditions the clay can only be carefully mixed into a uniform blend of slightly lower refractoriness, thus avoiding a particularly bad lot. Fusion tests generally give sufficient information as to the uniformity of a deposit. There are times, however, when a particularly siliceous or aluminous brick is desired and this necessitates chemical analyses.

Grinding

The influence of grinding on the product is rather well known; in general, the finer grinds result in the production of a dense firebrick while the coarser grinds produce one that is more open and porous. However, as in the case of concrete, the strongest block is not secured from the sand nor from the gravel, but by having the proper proportions of the different sized material. Fortunately, flint clay or grog assumes different sizes in grinding and a suitable blend is secured without great difficulty. As a precaution, however, some plants screen their grog to different sizes before incorporating it into the mix. The effect of grinding is also modified in the process of manufacture.

Proportioning

Proportioning is a problem that each plant must work out for itself as each plastic clay varies, in that some will bind considerable grog or flint clay, while others will not. Some plastic clays are very nearly as refractory as the materials they bind, while others are of lower refractoriness. Obviously, the permissible amounts of two such clays would not be the same. Another problem that confronts only the producer lies in the relative amounts of plastic flint clay and grog that are available, for he must proportion them in such a way that the maximum return is secured, unless he supplies some one particular trade for which a certain definite type of firebrick is required.

Notwithstanding the fact that 100 per cent. flint-clay bricks are sometimes made, the strength of a brick varies directly with the bonding clay, for the strength of all-flint bricks may be increased by the addition of plastic clay. A direct application of this principle lies in the manufacture of blast-furnace bricks, where the refractory requirements diminish and the strength requirements increase from the hearth to the top.

Tempering

The characteristics of a firebrick depend very largely on the amount of water used in its manufacture. The full plasticity of a clay is not developed unless sufficient water is added, and, conversely, the plasticity may be decreased by diminishing the amount of water used in its tempering. The proper amount of water that should be used in making the most dense or most porous brick varies not only with each individual mix but with each process of manufacture. The above figures, selected from several sets of data, illustrate clearly how, in general, the strength of each mix increases with the amount of water until a limit is reached, after which the further addition of water results in a slight falling off in mechanical strength.

Per Cent Water by Weight	Modulus of Rupture of Burned Piece	Porosity of Burned Piece
7.5	2491	24.0
9.0	6019	20.3
10.0	4020	20.6
Another mixture of the same clays.		
7.5	1891	23.35
9.0	5675	21.45
10.0	4670	21.50

Shaping

Regarding this step, from the standpoint of firebrick structures only, the most dense product should result from clays worked at stiff mud consistency, providing the necessary pressure is applied. Furthermore, a dry-pressed or hand-made brick must be fired to a higher temperature in order to secure the same effect. By the same reasoning, one would hardly choose the stiff-mud process for making an open firebrick.

Drying

Although this part of firebrick manufacture is a study in itself, it is of no particular interest to the consumer. It is true that cracks sometimes develop during the drying of large shapes, and these are often objectionable. It is also true that the color of firebrick is influenced by the water that remains in the brick as they are placed in the kiln, for the combination of sulphur from the coal and steam tend to bring the iron to the surface, giving rise to a pink discoloration. Advantage is taken of this fact in some localities, where it is necessary to set facebrick when they are quite "green," to obtain a sufficiently deep color. Tests have shown, however, that the pink-colored firebrick are often of the same refractoriness as the lighter products made from the same clays, although this color may be an indication of excessive impurities.

Burning

Burning is of prime importance to the consumer, who sometimes prefers a light-burned product, while in other instances he wishes one of a very hard burn. The writer does not feel that rule-of-thumb reasoning should be applied to this requirement and submits the curves given in Fig. 1 to show the effect of heat on different flint and plastic clays. To the manufacturer such curves are important in that they show which clays can be most successfully used in making dense or open firebrick for different purposes; and, while they cannot be expected to be made available to the different consumers, they do indicate what can be expected of the firebricks made from such clays when placed in service. They also act as a guide to the manufacturer in establishing his burning practice, for hardly any two clays require the same treatment in this respect.

When it is borne in mind that clays contract as their porosity decreases, during burning, the following deductions can be quickly and accurately drawn. A flint clay that has a burning behavior similar to A need not be burned to a very high temperature in order to make up a high-grade product. Its volume remains practically the same and when the bonding clay is mature few, if any benefits are gained by harder burning. Such a clay is undoubtedly responsible for the statement that certain bricks expand in service and hence give very good service in roofs. As a matter of fact, they can hardly expand more than usual but they do not contract.

A flint clay of type B, on the other hand, must be burned in the kiln to a high temperature if shrinkage during service is undesirable. The same statements also hold true in a slightly different way for plastic clays. For example, a plastic clay of type C becomes dense at a low temperature, and then remains very much the same over a wide range of temperature. Its full strength can be gained and its contradiction removed with no difficulty.

On the other hand, a plastic clay of type E must be burned to a higher temperature in order to remove its shrinkage, for such a clay continues to contract with increasing temperatures until the period of expansion resulting from overburning begins. A clay of type D is not at all uncommon. These plastic clays always retain their open structure and are not adapted to the manufacture of dense, abrasion-resisting bricks. Additional curves could be shown, but these are sufficient to show that all firebricks cannot, or should not, be burned in the same way. They also show how hopeless a task it is to apply any one set of clays to all kinds of service.

Installation

Were it not for the interest that the manufacturer of refractories must keep in his product until it is torn out, a success or failure, his responsibility would cease at the plant. It happens, however, that furnace practice and conditions vary so tremendously that repeated failures force him to "see" his product through to the end. A good many failures are simply accepted as such and are not investigated at all, others only superficially, and others are too complicated for solution. A few failures that have come to the writer's attention, and are not the manufacturer's fault, are briefly described here.

1. A high-grade firebrick fusing at a temperature exceeding 3,100° F. (1,700° C.) was laid up in a local loam that fused in the vicinity of 2,100° F. (1,148° C.). Parallel cases concern very cheap unsorted fireclay.

2. A similar firebrick was laid up with thick joints of a patent cement intended for another purpose but, due to the salesman's ignorance or overconfidence, was tried although it was not sufficiently refractory (fusion point 2,300° F.—1,260° C.) for that purpose.

3. A firebrick used in a furnace roof gave two weeks' service where six weeks' service was generally secured. Investigation of plant record showed that the coal at that time was extremely high in sulphur and afforded a very corrosive ash, which, when deposited on the roof, formed a slag that ate the brick. Tests made on the good ends of the failure proved the firebrick to be of the usual standard of refractoriness.

4. Lime came into contact with a fireclay brick, several of which in the hot zone reached with the lime to form a glass. Investigation of the ends proved the firebrick to be of the same quality of refractoriness that had previously given satisfaction. As there was no method for measuring temperature at this plant, the natural assumption was that the heat had become excessive and caused the usual reaction between fireclay and lime or magnesite. Lime is sometimes added to fireclay in order to secure a firm joint; it is difficult to understand why this is done, when manufacturers spend thousands of dollars each year to eliminate high-lime clays and secure those that are low in lime and other similar fluxes.

5. Stove bricks failed, due to a crumbling of the upper courses. The original bricks were of high refractoriness, but tests showed that a very corrosive dust had been deposited which lowered their refractoriness from about 3,150° F. to 2,400° F. Undoubtedly this dust, as it became heated and cooled or liquid and solid, exerted considerable disintegrating force. It is quite possible that one of the failures mentioned in the questionnaire replies was due to similar conditions.

6. Checker brick were reported as failures. Investigation showed that the bricklayer did not like their color, though fusion tests showed that they were of exactly the same refractoriness as the ones considered satisfactory. The tests also showed that a slag was deposited upon the surface of these bricks, which lowered their softening point of 3,175° F. (1,747° C.) on the inside of the brick to 2,540° F. (1,394° C.) on the exposed surface; also that the brick that had been condemned was more dense and, hence, more resistant to slag penetration.

At numerous plants, failures have occurred when sand, ashes, and other forms of insulation have been used. It must be remembered that radiation is often the one factor that saves a firebrick from quick failure. In removing this protection one should proceed with care, the factor of safety is being decreased and the firebrick is being subjected to more severe conditions, which may result in failure.

On the other hand, roofs sometimes "creep" or sag when made of inferior material that has been too lightly burned. Excessive erosion occurs when a firebrick is not sufficiently strong mechanically to resist this influence. Poorly molded, irregular blocks are also encountered.

It is very rare that a brick melts out unless it is contaminated with furnace dust or slag. Many experiences like the preceding could be mentioned were it necessary, but the one important lesson they teach is that they are costly and do not always give definite information. In order to avoid needless repetition, the manufacturer must know what kind of a product he is producing and the consumer must be thoroughly familiar with his working conditions. The manufacturer is trying to do his part and the consumer must do the same, for he will benefit the most. He must insist on the construction of furnaces according to blueprints and on the careful selection of mortar. He should also know what kind of brick are being installed, not only as to brand but as to burn, process of manufacture, and general characteristics. He should also be able to show temperature and tonnage records for different furnaces and the nature of the fuel or slag, or both, that will be in contact with the firebrick.

If better records are kept and the causes of failure are noted, there is no reason why many customers cannot secure the 100 per cent. better service secured at the one plant previously mentioned.

The manufacturer of firebrick, on the other hand, will be better able to make a product that is best suited for each installation or to state that his product does not meet the necessary requirements. If repeated failures occur at some plants, all parties concerned will be in a better position to know the cause or causes.

Solving Blast Furnace Flue Dust Problem

Explanation of Various Factors Entering Into Flue Dust Problem. Data on Comparative Blast Furnace Practice. Interesting Suggestions for Changing Blast Furnace Design to Reduce Flue Dust Loss

By R. W. H. ATCHERSON,
Blast Furnace Superintendent, Inland Steel Company.

BLAST FURNACE flue dust is one of the most troublesome operating factors in the iron and steel industry. It is usually involved in all the unpleasant phases of blast-furnace operations. It adds to our aggravations until we are willing to spend large sums of money to keep it out of our stoves and boilers and more money to handle it again and again on one scheme or another to induce the furnaces to retain it without bad after effects.

Several successful operators claim that it is useless to recharge raw flue dust because the furnace would never have blown it out if it had been suitable material for blast-furnace consumption. Most of us who have made persistent efforts to return raw flue dust to the furnaces have decided that it is very often false economy to do so. Yet some remarkable results have been attained at the Ohio Works of the Carnegie Steel Co. through recharging raw dust. The plant comprises six modern blast furnaces. Up to 1909, about 300,000 tons of flue dust had accumulated in stock piles. During the last 10 years, there have been recharged into these furnaces all of the flue dust recovered from the furnace operations, the entire stock pile of flue dust, and nearly 80,000 tons of dust shipped from other furnaces of the Carnegie Steel Co.

Table 1—Influence of Coke Hardness on Flue-dust Production.

Physical quality of coke	Soft and Open	Appreciably Stronger
Average coking time	18 hr. 51 min.	20 hr. 59 min.
Pounds flue dust produced per ton pig iron	301.9	152.5
Average daily tonnage of pig iron produced	537.6	532.5
Lbs. material consumed per ton pig iron produced:		
Coke	2,052.0	2,039.0
Ore, scale, and sinter	4,585.0	4,533.0
Bessemer slag	113.0	39.0
Limestone	1,037.0	1,018.0
Cu. ft. of air blown, at 60° F. per minute	43,949.0	44,214.0
Cu. ft. of air blown, at 60° F., per pound of coke	57.0	58.2
Blast temperature degrees F.	1,245.0	1,120.0
Blast pressure, pounds per square inch	18.5	18.8
Gas temperature, degrees F.	309.0	335.0
Gas pressure, inches of water	30.6	34.0
Average composition of pig iron:		
Silicon, per cent	0.98	0.83
Sulphur, per cent	0.032	0.031
Phosphorus, per cent	0.206	0.179
Manganese, per cent	2.09	2.32
Production over 1.25 per cent, silicon	0.00	0.00
Production over 0.05 per cent, sulphur	0.00	0.00
Composition of slag:		
Silica, per cent	33.43	33.50
Alumina, per cent	15.47	16.11
Sulphur, per cent	1.06	1.02

In common with a great many blast-furnace men, we have tried many schemes for reducing the amount of dust carried out by the gas and numerous ways of recharging it, in both the raw and the sintered state. We have operated on inconsiderable percentages of Mesaba ore and again have used nothing but Mesaba for years at a time. Yet we are still making a great deal of flue dust, probably not any more than the average blast furnace using fine ores, but the amount is still out of all proportion to any physical changes in our ores and has never been as low as in some furnaces that are being driven at about the same rate of pig-iron production.

Factors Affecting Flue-dust Production

Every raw material charged into the furnace and every piece of equipment employed in its operation affects the amount of dust carried over by the gas in proportion to its influence on the smooth, regular descent of the charge column and on the chemical reactions that must take place in the blast furnace. When Mesaba ores were first introduced, the frequency of blast furnace slipping and rolling caused very high losses in furnace yields; but a gradual development of furnace lines and equipment and a better understanding of how furnaces using these ores should be charged and blown, have greatly reduced flue-dust production. In 1902, the blast furnaces of the United States Steel Corporation used 43.8 per cent Mesaba in their ore mixtures and the loss in furnace yield averaged 3.6 per cent. During the last 10 years, over 80 per cent Mesaba has been used each year, yet the average loss for that period has been a full per cent less. In comparing individual furnaces in the same group or comprising furnace groups, however, it cannot be said that any true relationship exists between the furnaces using 60 per cent Mesaba and those using 100 per cent, when considering the flue dust produced or the loss in furnace yields.

(In the original paper as read before the Institute meeting, the author included a table showing the blast furnace practice during the years 1909 to 1919. The table is not shown here. It gave the following statistics: Total ore consumed; per cent Mesaba ore; tons, flue dust used; tons flue dust produced; pounds coke per ton iron; iron produced; actual yield, per cent; theoretical yield, per cent; per cent furnace loss or gain.)

Paper read before February meeting of the American Institute of Mining and Metallurgical Engineers, entitled "Blast Furnace Flue Dust."

The physical nature of the ores is the primary basis of all ferrous losses in furnace gas but it is rather difficult to compare the aptitudes of various ores to produce flue dust except by actual furnace demonstration. Sieve tests furnish a simple means for rough comparisons but do not distinguish granular, flocculent, or aqueous conditions. The effect of heat absorption on an ore, when driving off the chemically combined water, is far different from that when simply drying up or driving off the absorbed water. The latter is quiescent, whereas the former may be said to be eruptive or analogous to a multitude of infinitesimal explosions, which fairly blow the ore to pieces. Ores that rank well on sieve tests may dust badly on account of their combined water. These actions may be better appreciated by considering the enormous volume of gas produced by the furnace and the quantities of ores reduced during a relatively short period of time. Only the filtering action of superimposed ore charges prevent far greater losses.

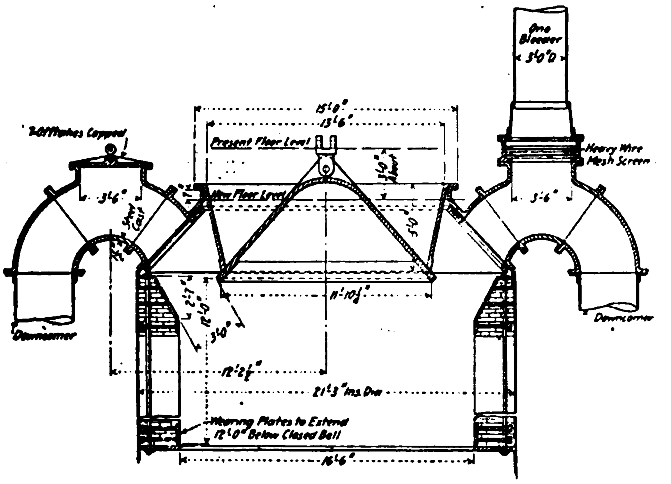


Fig. 1—The author believes that much of the material now carried over by the gas might be retained by a furnace with ample gas areas in the furnace top and downcomers. The sketch shows the section of a proposed furnace top. This top is further illustrated in Fig. 2.

The importance of properly grading and thoroughly mixing each grade of ore is readily appreciated when we consider how absolutely essential it is to keep the physical and chemical balance of the slag at all times as nearly a constant as possible. Occasionally, we are obliged to use raw materials without the guidance of an accurate chemical analysis or without a previous knowledge of the physical structure or characteristics. The results on the product and the practice of the blast furnace are invariably detrimental. It usually takes several days of experimenting of an empirical nature to bring the furnace back to normal action, which is only attained by correcting the slag balance. The causes and effects of disturbing this balance with the attendant increase in flue-dust production are too well known for detailed discussion.

I believe that much of the opposition to the use of fine ores in blast furnaces is superficial and prejudicial. Burdens composed entirely of fine ores are being very successfully handled by furnaces built on lines as developed today. High flue-dust production, where prevalent with high percentages of fine ores in the burden, is frequently due to an improper mixing or sizing of the ores. Where no thorough effort is made to counteract the natural segregation of lumps and fines at each rehandling from the mines to the furnace, there are bound to exist in the blast furnaces strata of ore of a finer consistency than contiguous layers. The obvious requirements of these finer and denser layers is an augmented gas pressure, sufficient to force through the denser layer. This action is rather more violent than would be the normal flow of gas and is attended by a greater disturbance of the stock, resulting in a larger production of dust than would follow the passage of the gas through the more open layers of ore. As a means of limiting the segregation of the flues into layers in the furnace, the method of charging is of incalculable value as a corrective feature but is not sufficiently thorough to counteract indifferent handling at the mines and docks. The intimate mixture of each ore into a uniform material physically also brings about a much desired chemical equality.

We acknowledge the existence, from a practical operating standpoint, of an irreducible minimum of flue-dust production for each grade of raw material with a given rate of furnace travel but, especially in the case of granular flue dust, we believe that much of the material now carried over by the gas might be retained by a furnace with ample gas areas in the furnace top and downcomers, as shown in Figs. 1 and 2.

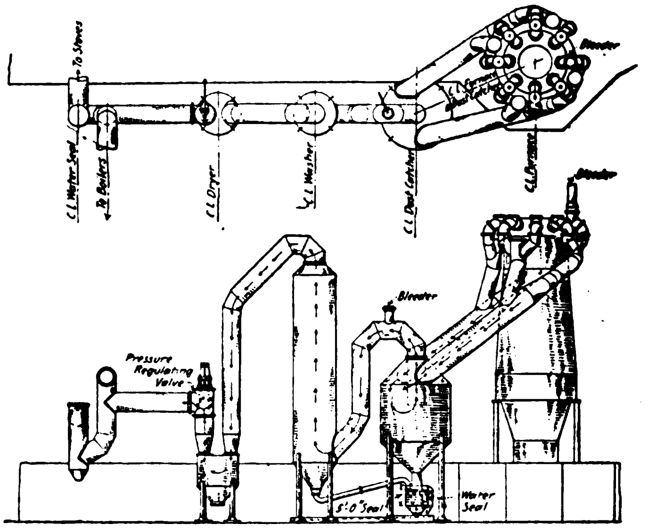


Fig. 2—The author feels that there is no justification for the high gas risers on modern furnaces and suggests a trial of the construction as shown above. The loading, transporting and unloading of hot flue dust has caused so many serious accidents, is such an expense and makes it so nearly impossible to keep a furnace plant clean that even the material deposited in primary dust catchers should be sluiced continuously from the catcher direct to the settling basin as shown in the above illustration.

From any view point, coke is the very life blood on which the whole smelting process depends. The physical structure of the coke has a very much greater influence on every phase of blast furnace practice than has the structure of any of the other materials. As indicating the effect of soft coke on flue-dust production, the following comparative statement is given, covering two operating periods on the same furnace under apparently identical conditions aside from the coking time on the by-product ovens. While using the soft coke, so much of it was dissolved in the furnace stack that it was found advisable to decrease the volume and increase the temperature of the blast and to charge additional coke while it was also necessary to use several times the normal number of scouring charges of Bessemer slag to keep the furnace working smoothly. The results shown for both periods are considerably below the average work of the blast furnace under consideration. About a month after the close of the second period, the coke was still further improved by a change in the coal mixture and the furnace also gained the advantage of a somewhat high grade ore mixture. It is worth noting the improved results shown in the following statement, except the rate of flue-dust production which increased as the furnace traveled faster in spite of the furnace working very smoothly. Not a pound of scrap of any description was consumed by the furnace during any of these three periods. In any consideration of this nature, it is highly important to exclude from comparison with normal blast-furnace practice the performance of those furnaces that combine the smelting of iron ore and the cupola function of melting scrap. Variable limestone causes irregular operations on a few furnaces but so much high-grade fluxing stone is available at a moderate price that this trouble is usually rectified.

Table 2—Comparative Blast Furnace Practice.
Period Ending April 1, 1919.

	Mark Mfg. Co. No. 1, 3 Months	Inland Steel Co. No. 3 12 Months
Total pig iron produced, tons	52,101	205,353
Average daily production of pig iron, tons	578.9	569.0
Average daily production of pig iron per 100 cu. ft. essential furnace volume	2.59	2.86
Pounds coke consumed per ton iron produced	1,976	1,526
Pounds stone consumed per ton iron produced	901	918
Pounds Bessemer slag consumed per ton iron produced	85	22
Pounds ore consumed per ton iron produced	4,323	4,056
Pounds scale consumed per ton iron produced	95	125
Pounds scrap consumed per ton iron produced	42	8
Pounds scrap produced per ton iron	41	134
Pounds flue dust produced per ton iron	73	290
Pounds sintered dust consumed per ton iron	none	72
Average cubic feet air blown per minute at 60° F.	40,088	44,190
Average cubic feet air blown per pound coke at 60° F.	49.9	56.0
Air blown per minute adjusted to 56 cu. ft. per lb. coke	45,000	44,190
Average blast temperature, degrees F.	954	1,002
Average blast pressure, pounds per square inch	16.4	19.7
Number of tuyeres actually blown through	9	12
Size of tuyeres actually blown through	5 in. and 6 in. × 12 in.	5½ in. × 12 in.
Average gas temperature, degrees F.	334	297
Average gas pressure in inches of water	42	35
Average per cent of water added to ore charged	none	0.9
Average composition of iron produced:		
Silicon, per cent	1.04	1.04
Sulphur, per cent	0.03	0.035
Phosphorus, per cent	0.19	0.297
Manganese, per cent	1.09	2.03
Average composition of slag produced:		
Silica, per cent	34.55	33.23
Alumina, per cent	14.75	15.92
CaO, per cent	46.16	44.80
MgO, per cent	1.98	1.95
Sulphur, per cent	1.54	1.42
FeO, per cent	0.46	0.71
MnO, per cent	0.91	1.97
Per cent of pig iron over 0.050 per cent sulphur	2.34	Not recorded
Per cent of pig iron over 1.25 per cent silicon	12.39	Not recorded
Per cent iron between 0.75 and 1.25 silicon and not over 0.04 sulphur	Not recorded	73.39
Method of charging:		
Dump large bell	Coke .... 9,200 Ore .... 22,500 Stone 4,500	Ore .... 14,000 Coke .... 3,700 Stone 5,000
Dump large bell		Ore .... 14,000 Coke 7,400
Essential working volume:		
Height from tuyeres to 6 ft. below bell	71 ft. 2 in.	69 ft. 0 in.
Height from tuyeres to top bosh plates	12 ft. 4 in.	12 ft. 8 in.
Height from top bosh plates to stack batter	5 ft. 0 in.	9 ft. 5 in.
Height of stack batter	44 ft. 0 in.	38 ft. 7 in.
Height from stack batter to 6 ft. below bell	8 ft. 1 in.	8 ft. 4 in.
Diameter nose to nose of tuyere coolers	19 ft. 6 in.	17 ft. 3 in.
Diameter nose to nose of top bosh plates	22 ft. 2 in.	21 ft. 9 in.
Diameter of lining at bottom of stack batter	22 ft. 6 in.	21 ft. 4 in.
Diameter of lining at top of stack batter	17 ft. 0 in.	16 ft. 6 in.
Diameter of lining 6 ft. below closed bell	17 ft. 0 in.	16 ft. 6 in.
Volume calculated from above dimensions	22,371	19,891
Bosh angle tuyere coolers to top bosh plates	79° 54'	79° 56'
Bosh angle of brick work	79° 57'	80° 43'
Stack batter in inches per foot	0.75	0.75
Angle of large bell	50°	50°
Diameter of large bell	13 ft. 0 in.	12 ft. 6 in.
Travel of large bell	2 ft. 0 in.	2 ft. 2 in.
Stock line protection plates below bell	12 ft. 6 in.	9 ft. 4 in.*
Stock level below closed bell	4 ft. 0 in.	3 ft. 4 in.
Stock level below bottom of gas off-takes	4 ft. 8 in.	2 ft. 6 in.
Stock level to stack batter	10 ft. 0 in.	11 ft. 0 in.
Closed bell to downcomer openings in uptake	24 ft. 0 in.	24 ft. 0 in.
Total area of gas off-takes in square feet	28.5	38.5
Total area of downcomers in square feet	20.2	37.4
Total area of downcomer openings to dust catcher, in sq. ft.	20.2	20.7
Total area of dust catchers in square feet	254.3	452.4
Total area of gas main exits from dust catchers in sq. ft.	28.3	28.3
Brassert washer	15 ft. × 54 ft. 2½ in.	15 ft. × 54 ft. 2½ in.
Brassert dryer	12 ft. × 16 ft.	12 ft. × 21 ft. 5½ in.
Area of stove gas main in square feet	12.7	28.3
Area of boiler gas main in square feet	38.5	blanked
Area of by-pass to stoves on No. 1 and No. 2 furnaces		9.6
Number of casts per 24 hours	5	6
Time lost per 24 hours stopping iron hole	25 min.	11 min.

*Stock line protection plates will be extended to 12 feet below bell.

The question of the most suitable lines for our

Pounds flue dust produced per ton pig iron	196.9
Average daily tonnage of pig iron produced	601.9
Pounds material consumed per ton pig iron produced:	
Coke	1,876.0
Ore, scale, and sinter	4,291.0
Bessemer slag	21.0
Limestone	819.0
Cubic feet of air blown per minute at 60° F	45,208.0
Cubic feet of air blown per pound of coke at 60° F.	56.5
Blast temperature, degrees F	1,186.0
Blast pressure, pounds per square inch	19.7
Gas temperature, degrees F	301.0
Gas pressure, inches of water	32.7
Average composition of pig iron:	
Silicon, per cent	1.05
Sulphur, per cent	0.032
Phosphorus, per cent	0.145
Manganese, per cent	1.64
Production over 1.25 per cent silicon	7.10
Production over 0.05 per cent sulphur	none
Composition of slag:	
Silica per cent	32.10
Alumina, per cent	18.75
Sulphur, per cent	1.18

present blast-furnace practice has been discussed so often that I will simply give the general dimensions and results obtained on two furnaces built on about what is now generally conceded to be acceptable lines. The only contrast in operating results is in the remarkably small amount of flue dust produced by the Mark Manufacturing Co. furnace. The superintendent, Mr. Arthur Baer, gives nearly all the credit to the uniform volume of air supplied by a turbo-blower. The reciprocating engines, for the Inland Steel Co. furnace shown, usually run about 116 r.p.m. The pulsations of the engine strokes can be entirely neglected after the long tortuous course of the blast through the long cold blast mains, large hot blast stoves, hot blast main and bustle pipe. Most blast-furnace men agree with Mr. Baer that his turbo-blower gives some advantages in compensating for atmospheric changes but the dominant effectives in his low dust production are raw materials, furnace lines, and operating methods. This contention is strengthened by the fact that numerous other turbo-blown furnaces show considerably higher losses.

The important consideration is not the type of blower but rather the variation in air delivery from one minute to another that causes irregular movement of the stock, with consequent high flue-dust production. This variation of reciprocating engines is especially noticeable at some of the plants where the blast-furnace and rolling mill steam lines are connected. The steam pressure will vary 25 or 30 lbs. within a few minutes and no governor on reciprocating engines will govern within two to three revolutions of a given point under varying steam pressure. We will grant that it is difficult to build a governor to answer the requirements of blowing engines but, at the same time, there has been absolutely no improvement in this line for the past 20 years. The governing of turbines has been highly developed to keep step with the exact requirements of electrical generation development. It was a simple step to adapt this governor to a turbo-blower and that, with atmospheric regulation, has given a very valuable blast-furnace air compressor. We are unable to compare the ores used at these two plants, either by analyses or sieve tests, but it is interesting to note that no water is ever added to any of the materials charged into the Mark furnace and none of the flue dust is recharged.

Next in importance, after considering the raw materials and furnace equipment, would naturally be the velocity of the gas as it leaves the furnace; but this question has become rather involved because so few operators attempt to determine the velocity of gas in the downcomers and simply judge the dust-carrying capacity of the gas by the volume of air blown, the blast pressure, or the gas pressure at the furnace top. The causes and effects of high blast and gas pressures are very often misconstrued. A most recent blast-furnace treatise now widely circulated states:

"It is very evident that to secure free and regular settling of the charge, one of the prime conditions is to have the blast pressure low in relation to the weight of the charge column—high blast pressure is an unmitigated evil and in general the lower the pressure with which a furnace will work, the more satisfactory its work will be."

I would take exception to that statement unless qualified by designating the conditions to which the high pressure is due. Large blast furnaces have been operated on very low blast pressures, where the advantages of carrying the slag decidedly acid were permitted to outweigh all other considerations. On the other hand, exceptionally good blast-furnace performance is being made on 20 lb. blast pressure where 4 or 5 lbs. of that pressure are due to back pressure from gas washers and gas mains and to a fairly viscous slag and not due to scaffolding of the furnace or improper penetration.

The effect of density of the gas on ore reduction in a blast furnace holds a large interest. The best operating results have been attained on furnaces with high gas pressures but there is a question whether the intensity of the gases is the direct cause of the difference noted in furnace performance or whether the increased back pressure of perhaps 1 lb. per sq. in. above normal sufficiently increases the blast pressure to materially accelerate combustion of the coke. In this connection, it must be borne in mind that the capacity of gas for carrying flue dust varies as the square of its velocity so that a nominal reduction in the volume of blast blown into a furnace should, and usually does, cause a decidedly decreased flue-dust production; that top pressures normally are a function of the volume and density of the gas leaving the furnace, the frictional resistance of the downcomers and gas mains and the area of the gas-burner openings; that the advantages gained by increasing the furnace area above the point where the charges of raw material strike the furnace wall, thereby decreasing the velocity of the gas and permitting the location of gas offtakes well above the stock level, must be recognized.

Suggested Downcomer Arrangement

Having in mind the foregoing conclusions, we have designed an unusual arrangement of downcomers for reducing the exit-velocity of the gas leaving the furnace, for equalizing the flow of gas over the entire furnace area, and for controlling the gas pressure inside the furnace. The system is designed so that the gas will travel practically the same distance from each furnace opening to the dust catcher and the swirling effect inside the dust catcher is on a balance as well.

The writer feels that there is no justification for the high gas risers on modern furnaces and suggests a trial of the construction shown in Fig. 2. Under this plan, it is proposed to control the gas pressure with a throttling valve on the gas outlet from the last unit of whatever gas-cleaning system is used. At first the regulating valves were placed as close to the mouth of the downcomers as practicable and the off-takes were carefully proportioned so that heavy material would be deflected against the concave surface of the throttling valves and absolutely stopped, causing at least some of it to fall back into the furnace, even against the flow of the gas, see Fig. 3. However, objections to that location developed. It is primarily desired to promote the intensity of the gas without increasing its velocity until after it has deposited its dust in the primary dust catcher and gas washer. Also, it is the intention to have these valves set for the pressure it is desired to maintain in the furnace and yet have them afford relief from the rush of gas following furnace slips or rolls. Throttling valves in the gas off-takes might work so slowly as to endanger the furnace top whereas a valve remote from the furnace would utilize the receiver effect of downcomers, dust catcher, and gas washers, thereby dissipating the force of violent slips.

Volumes have been written describing the various methods of removing flue dust from furnace gas. The writer believes steel-wool gas cleaners will be developed to practical usefulness but, in the absence of this development, favors the tower type of wet washers such as the Zschocke, Diehl, or Brassert. It is true these washers waste the sensible heat of the gas, but they have proved to be wonderfully efficient and reliable gas cleaners. As a further development, the writer believes we shall discover a combination of flotation and hydraulic concentration of gas-washer sludge that will wash the coke dust out of the flue dust and furnish a material no more difficult to reduce in furnaces than is the finest ore. This may possibly be accomplished by some elaboration of the Dorr thickener. The dust thus concentrated could be pressed into briquettes for open-hearth furnaces or used to advantage in the manner suggested by Mr. Brassert for utilizing washer sluge by piping it to the skip pits where a measured amount is added to each skip or ore

The loading, transporting, and unloading of hot flue dust has caused so many serious accidents, is such an expense, and makes it so nearly impossible to keep a furnace plant clean that even the material deposited in primary dust-catchers should be sluiced continuously from the catcher direct to the settling basin, as shown in Fig. 2.

About 12 years ago, at the Bellaire furnaces of the Carnegie Steel Co., we converted the dust catchers into rough contact washers by filling the cone sections with water constantly discharging through a water seal constructed of standard pipe fittings. The object was to increase the gas-cleaning efficiency of the dust catchers but, at the same time, a more desirable method of handling the flue dust was gained. By allowing the heavier dust to settle, enough of the coke dust was floated off as lighter material to permit the successful recharging of all fine dust recovered. This condition prevailed even when the 12 ft. and 12 ft. 6 in. hearth furnaces were driven to an average production of over 400 tons of iron per day, in spite of increased production of the flue dust and a coincident consumption to as high as 400 lbs. of flue dust per ton of iron produced. It would seem that the elements of washing out the coke dust have generally prevailed wherever flue dust has been successfully recharged. Such an assertion would also explain the superiority of weathered stock-pile dust. J. W. Dougherty's proposed method of feeding raw dust through the furnace shell, by means of a worm gear, was given some publicity a few years ago, but it is so nearly a mechanical impossibility to introduce any material below the stock level of a furnace and yet distribute it uniformly over the full furnace area that his suggestion was never considered seriously.

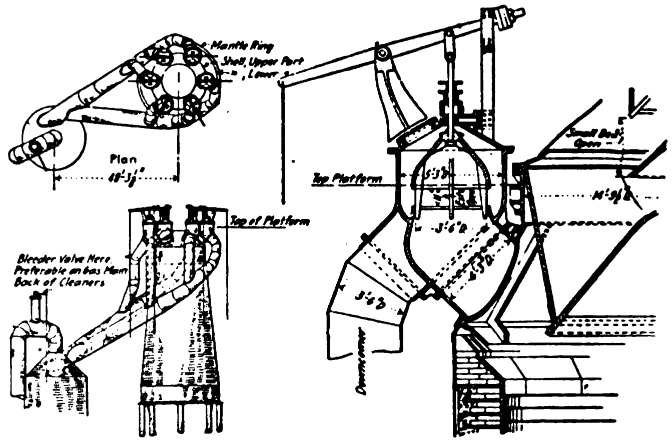
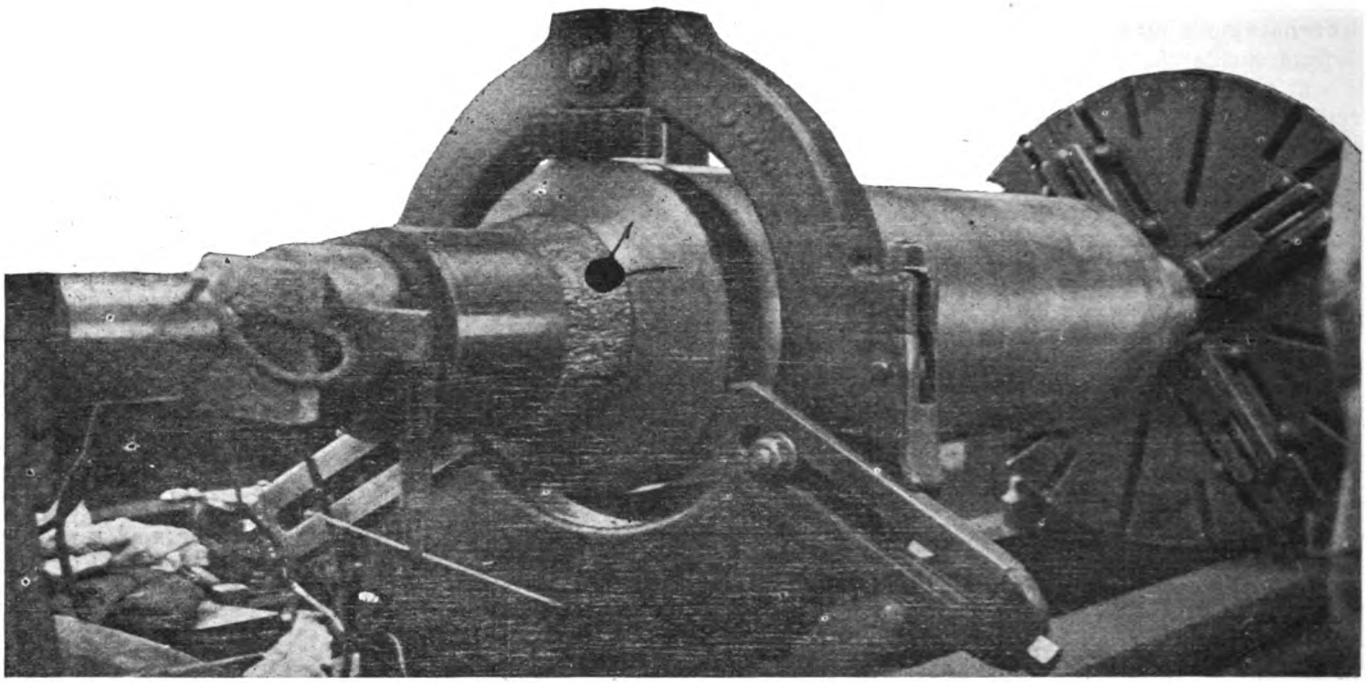


Fig. 3—Proposed gas-regulating valve for downcomers.

It is well known that flue dust contains carbon sufficient to sinter it readily (in either the Dwight-Lloyd or Greenawalt machines into an excellent material for adding to the ore burdens. Briquetting by using some binding material or sintering action, direct roasting, or sintering and nodulizing in rotary kilns are all in practical operation. While the product of these heat-agglomerating processes has a tendency to make the furnace charges more open, it also has a disadvantage in the important consideration of fuel economy. These products invariably are formed as silicates of iron and as such form the most irreducible material that is charged into the blast furnace. In general, we may say that no one but the actual operators can begin to appreciate the countless difficulties encountered in attempting to handle flue dust efficiently and economically for any of the foregoing processes. In the first place, if the dust is handled on a purely manual basis, the labor cost becomes prohibitive. Secondly, if elaborate and expensive machinery is installed to get away from the high labor cost, the wear and tear on the machinery prevents the success of the plan. But we may safely say that the cost of any of these processes is far in excess of that for simply floating off the coke dust.



A five-ton cast iron roll welded with alternating current arc. Although this illustration does not show a steel mill roll, it does illustrates the possibilities of welding cast iron. The black mark indicates locality of weld.

Recent Welding and Cutting Developments

Description of Various Processes of Welding and Cutting and the Modern Equipment Employed—Special Reference to Applications in Steel Industry Shows Many Possible Uses.

By R. M. RUSH,
President, Rush Machinery Company, Pittsburgh, Pa.

WELDING and cutting of metals by the oxy-acetylene and electric processes have become a very important factor in the production of iron and steel. A few years ago a cutting torch was a curiosity. Today it is a necessity in the iron and steel plant. One mill alone in the Pittsburgh district uses over 200 gas cutting outfits. Electric welding was comparatively unknown in the steel industry two years ago. Today practically every steel mill has at least one electric welding outfit and some of the larger works have six or more. Electric rivet cutting and scrap cutting outfits are just being introduced. Soon they will find their place among the necessities of efficient mill operation.

The war acted as a great stimulant on the metal cutting and welding industries. Through various government agencies knowledge that in many cases had been considered a trade secret, was collected and made available for general use.

Foremost among these agencies was the Emergency Fleet Corporation. Realizing the tremendous advantages to be gained in the building of ships by the application of metal cutting and welding, a committee was formed composed of executives and engineers from practically all the corporations in America connected in any way with the welding or ship building industries. Scientific men, equipment manufacturers and practical shipbuilders working together in this committee did more for the art of welding in one short year than had been accomplished in a decade of individual effort.

The results of this work are now apparent in the industrial world. Labor saving processes are more in demand than ever before, due to the greatly increased cost of labor and its scarcity, and new methods are imperative. The world's great demand for increasing production in every line, and especially for steel, means that shutdowns are more costly than ever.

These shutdowns are being eliminated or shortened by the use of welding and cutting equipment. Today there are being accomplished in steel mills, repair jobs, which in magnitude and importance, are second only to the great repair jobs that put the injured German ships in service so quickly at the time we entered the war. Large bedplates and cylinders have been repaired with a gang of skilled welders working from Saturday noon to Monday morning, that in former years would have required mill shut downs of several weeks.

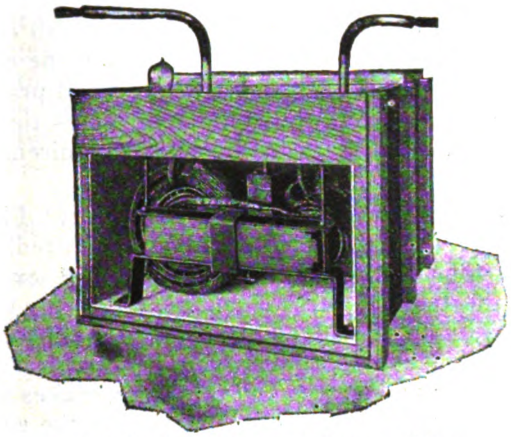
Rapid development in the use of cutting and welding equipment in the steel mills has been accompanied by like accomplishments among the manufacturers of equipment. The purpose of this article is to briefly describe some of the recent developments in this field.

Welding equipment may be divided into the following classes: First, gas welding with the acetylene torch; second, electric arc welding with carbon and metal electrodes; third, butt, spot or seam welding with electric resistance equipment. Metal cutting is divided into two classes—gas and the electric arc.

Of these, from the steel plant operators' standpoint, the electric arc is of the most importance for welding and the gas cutting torch for cutting, except for rough cutting, such as scrap for charging and very special cutting such as seams in blooms, which may be done with the electric arc.

Electric Arc Welding.

The greatest step in advance in electric arc welding that has been made for many years has been the application of alternating current through properly designed transformers, with results as good as or better than with the complicated and expensive motor generator sets which has always heretofore been considered necessary for arc welding. Steel men have hesitated in installing equipment that was so easily put out of commission as the commercial arc-welder motor generator set of the past. If, as is now possible, an arc welder can consist of a simple transformer which is easily portable to the job, there is no excuse for any steel or blast furnace plant being without an arc welding equipment.

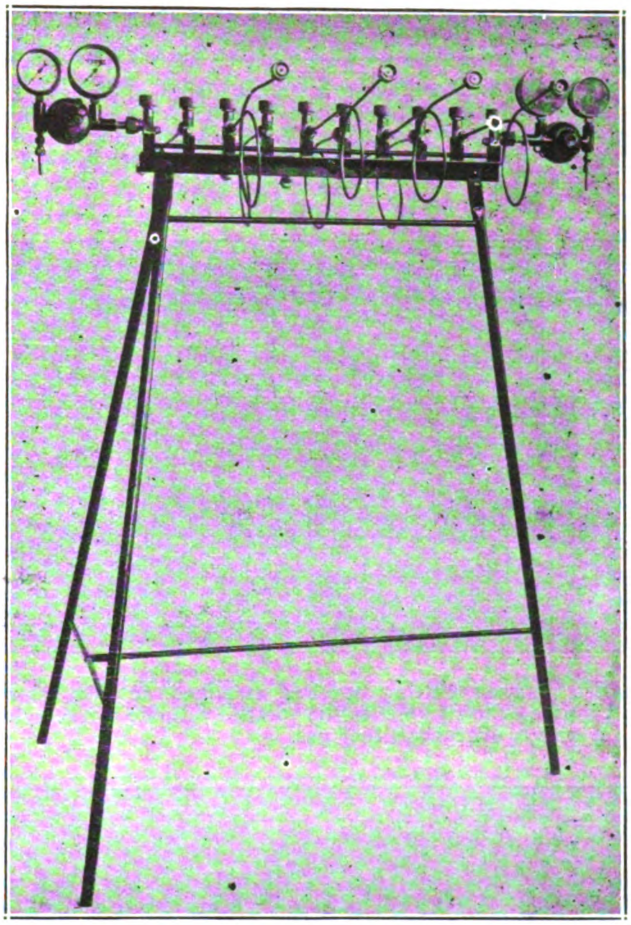


Internal view of ac welding machine.

A. C. equipment being the latest development in the field of arc welding naturally had to prove itself. The investigation made by the U. S. Shipping Board on all arc welding systems fortunately gave a public opportunity for comparison of ac with dc. Every manufacturer and user of arc welding apparatus was invited to participate in tests and there were many dc equipment and systems used, but only one ac, that of the Electric Arc Cutting & Welding Co., Newark, N. J. The welds made by this ac system were the only ones which, under tensile test, broke outside of the weld and under cold bend and alternating stress tests these same test pieces were equal to if not better than the average of the dc test pieces.

H. A. Horner, in the A. I. E. E. Proceedings, Vol. 37, No. 10, page 1,190, says: "It is interesting to observe that the best one of these tests were made with a coated (not an asbestos covered) electrode, using alternating current."

The grade of electrode is a separate subject from that of the grade of equipment, but the best machine and the best electrode with the best operator is a winning combination. A good operator may make a passable job with poor tools, but he will always do better work and take more pride in it if he has the best tools obtainable. No operator, no matter how skillful, can, with a poor grade of wire, make as good a job as he could with a good grade of wire, and we consider the best electrode is none too good in arc welding. The cost forms such a small proportion of the total cost, and results are so important that the two items of machine and electrode should not be neglected.

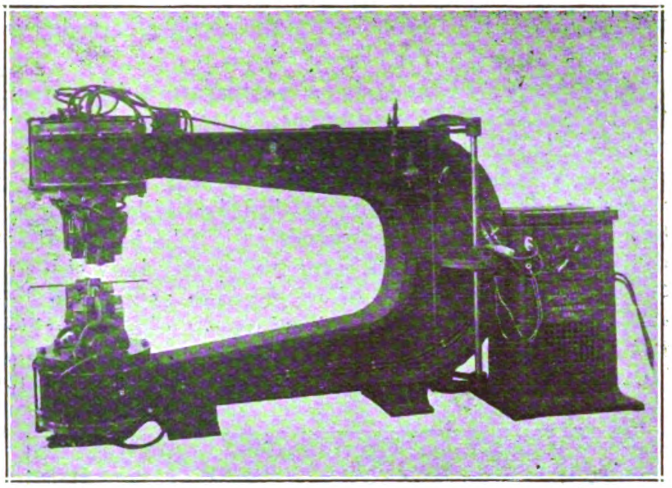


Manifold for connecting oxygen tanks together used in cutting or drilling salamanders or for very heavy steel cutting.

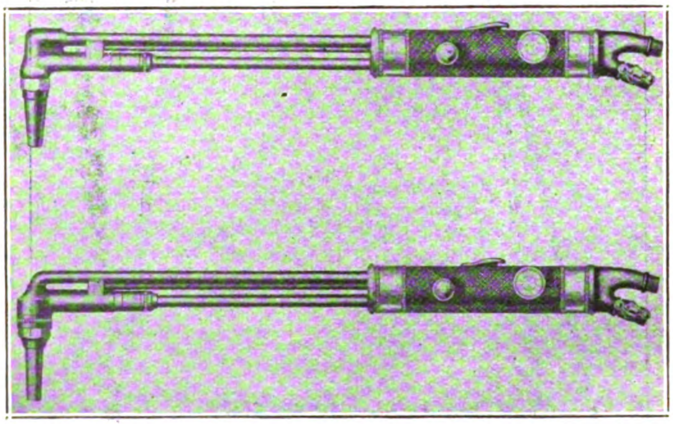
To sum up, a good man will take pride in and do a good job with good tools, whereas with poor tools and material he is more likely to slight his work.

There are various grades of bare wire on the market and one American company puts out a flux coated wire, a new idea in that the oxides and nitrides are attacked chemically by the coating and pass off as a gas, leaving no slag over the weld or chance of slag inclusion in the weld.

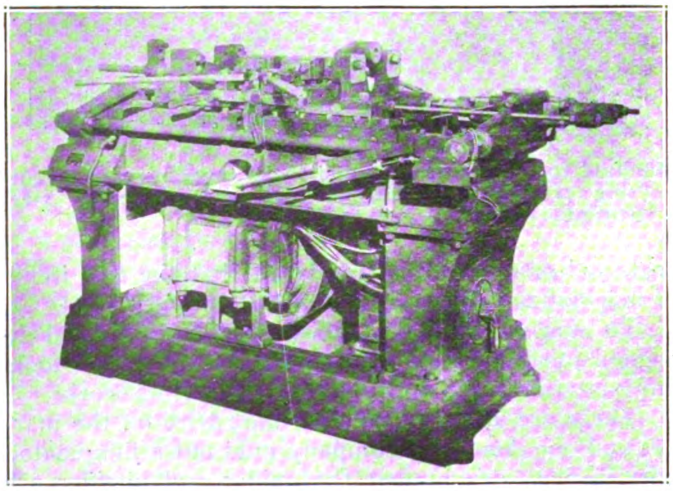
Alternating current is admitted by the results of many successful tests into the field of successful operation for arc welding and possesses the following ad-



Multiple spot welder having a 60-inch depth of throat. This machine is operated by air cylinders, has a maximum welding capacity of two pieces of 5/16 inch, and is designed especially for the welding of steel beams, etc. It makes two spots in parallel at once.



Modern oxygen cutting torches arranged so that simply changing the tips makes the torches suitable for acetylene or any hydrocarbon fuel gas.



Butt welder equipped with hydraulic jack, horizontal hand clamping device. The machine is arranged with oil cooled transformer and is particularly adapted for welding automobile rims, drop forgings, steel frames, butt welding large sections of high speed steel and all work requiring accurate alignment and rapid production in quantities. It is also a very adaptable machine for pipe of a cross section within the capacity of the machine.

vantages. It is electrically right, in that it will operate from the designed power supply. In other words, it can be attached to the 220 or 440-volt alternating current with two wires on one transformer, whereas direct current motor generator sets require on the same power supply three wires and two or three transformers. Furthermore, a dc motor generator set is tied down to a foundation and its radius of action is only equal to the length of its dc leads. It is true that dc sets are sometimes equipped with a chassis and wheels, but this only makes them the heavier. Alternating current equipment weighing but 250 lbs. is really portable and hence can be used around the shop or yard, attaching to the existing power line without the expense of wiring the motor set at the low dc voltage. In other words, it is electrically wrong to wire for 50 volts when you can wire for 220 or 440 volts. Theoretically it takes 16 times as much copper for the same installation on 50 volts as it does on 220. Besides the electrical considerations of the ac system, the single operator unit is ideal in that, like a filing system, machines can be added singly or in banks as required, and one operates as efficiently as all of them. Moreover, the location of part of them can be changed without any loss of operating efficiency and practically no loss of time. With dc equipment one is tied down to his original guess as to the future requirements of work in question.

Other advantages of ac equipment are: First, its efficiency. That is, a transformer is admittedly more efficient than any other sort of apparatus except an electric heater and this, of course, shows in the cost of operation to the advantage of ac equipment. Second, maintenance—a transformer has the least maintenance of any apparatus and this again makes a favorable showing in the cost of operation for the ac equipment. There are many theoretical considerations where the ac arc has an advantage over the dc, such as penetration, smoothness of deposition and absence of electrolytic corrosion.

Some welding machines strive for constant voltage and others for constant amperage, but the rate of heat transfer is the watts supplied to the arc, which is the product of both current and voltage. The ac machine has been designed to give a constant product of these two factors determining the heat rate of transfer and in the working of molten steel when the correct adjustment of heat transfer is reached it is important to so hold it.

Gas Welding.

An interesting question is when and where gas welding is better than electric arc welding and vice versa. The answer, as we have experienced it, is that for very thin work, i. e., less than 18 or 20-gauge, or where a very smooth finish is desired, gas welding is preferable; while for very heavy work, i. e., ⅛ in. and up, electric welding is more economical. The heavier the work the more it pays until, at 1 in. thickness and over, the cost of electric welding is not more than one-tenth that of gas welding.

Such work as safety guards for gears, couplings, etc., and all light steel work of any description is suitable for gas welding. An electric arc operator must be exceedingly skillful to accomplish this light work, which can be done very easily with an oxy-acetylene torch.

In the past. oxy-acetylene torches have all had drawbacks which have retarded their universal adoption. One of these is the tendency to flash back—in other words, for the flame to travel back into the torch and burn it up and burn up the hose and very often injure the operator. The speeding up of production during the war and the large increase of inexperienced operators in welding and cutting have resulted in many accidents and caused manufacturers to turn their attention to the matter of safety.

About two years ago an acetylene welding torch was placed upon the market by the Torchweld Equipment Company of Chicago, Ill., which practically revolutionized the gas welding business. It embodied a new principle—that of mixing the oxygen and acetylene in a carefully designed mixer back of the head of the torch in such a way that the theoretically correct proportioning of gases was possible and a neutral flame was automatically maintained. This resulted in better welds and large gas and oxygen savings. The use of this mixer was only made possible, however, by means of a flashback chamber consisting of a pocket of mixed gases which discharged whenever the flame tended to propagate back to the mixer. In simple terms the net result was that an inexperienced welder can produce good welds and maintain the proper flame with very little practice. Over 400 of these were used by one manufacturer of Liberty motors with untrained operators.

Resistance Welding.

Butt and spot welding is not as well known as gas or electric welding in the steel industry. There is, however, quite an application for this sort of welding and every steel mill machine shop should have at least one resistance welder in its machine tool equipment.

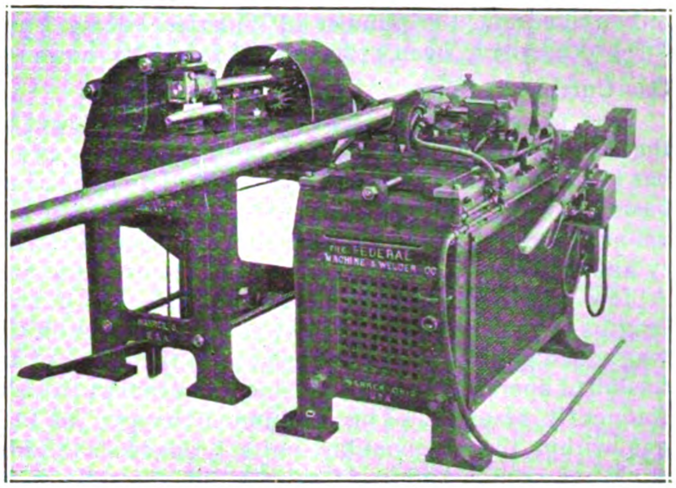
The accompanying photographs illustrate some of the recent developments in this art made by the Federal Machine & Welder Co., Warren, O. They are mainly mechanical improvements and better arrangements for applying pressure and electrical current in the proper manner for the job on hand. Welds produced in this manner are replacing rivets in many industries and often show physical characteristics 40 per cent stronger than riveted joints.

Two plates as thick as 1½ in., or even thicker, may be welded by this spot welding process. The usual applications, however, are on thinner stock. Above 16-gauge material 120 welds a minute may be made.

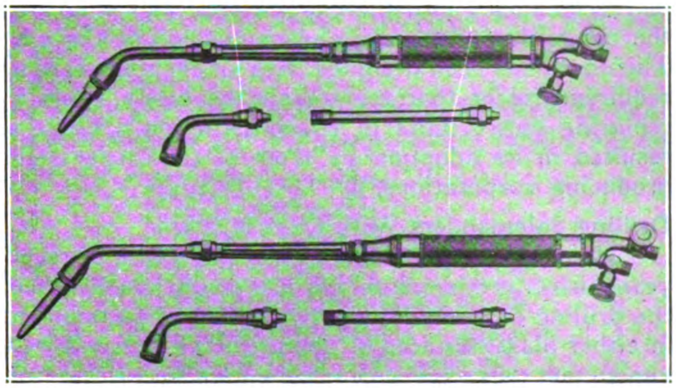
In butt welding, the work to be welded end to end, is clamped rigidly by means of a hand or air pressure clamp and the ends are brought together under pressure while the current is applied. This process is applied to pipe and solid sections. Other applications include rims and similar sections.

One automobile manufacturer is welding 400 automobile rims an hour with one machine. Others have developed similar production on other kinds of work.

Various forms of seam welds are being made on machines especially designed for the purpose. Tea ket-



This machine is for welding pipe up to 2¼ inches diameter and shows the roller which is used in connection with the machine for reducing the flash at the weld after the welding operation. This machine as originally designed for safe ending of boiler flues in the railroad shops of the Norfolk & Western Railroad.



Typical acetylene welding torch, showing extensions for heavy work and two angles of head.

A 600 ampere alternating current arc rivet cutting outfit carried by two.

tle spouts stamped originally in two sections are rapidly welded and the number of imperfect pieces from the process have been reduced to practically nothing.

Gas Cutting Torches.

The oxygen cutting torch is very well known in the steel industry, but until recently very little effort has been made to design a tool on a strictly engineering basis. During the past few years there has been developed equipment which from the standpoint of safety and efficiency has practically revolutionized the art. A few years ago a cutting torch consisted of two lengths of ordinary tubing screwed into castings, a tip was added and the instrument placed in the hands of an unskilled operator for use. It is no wonder that trouble frequently resulted. The addition of oxygen to fuel gas within the combustion limits produces a highly explosive combination. If this is not correctly handled it is obvious that trouble must result. The explosions in the torch and back into the hose, the flashbacks and burning in the head, have, in the best modern equipment, been eliminated. The accompanying illustration shows a modern cutting torch which has been provided with the gas mixer and flashback chamber of the welding torch and in addition a special check valve on the oxygen line which prevents the seepage of fuel gas back into the oxygen hose and eliminates the dangerous flashbacks and explosions of the past. This torch has been designed with an eye to steel plant requirements in that repairs can be easily made by replacing entire units in its construction. This has resulted in its adoption by most of the larger steel-producing corporations.

Drilling Salamanders With Oxygen.

One of the very interesting developments of recent years in connection with the use of oxygen has been the drilling and sometimes the cutting of salamanders in either blast furnaces or open hearths. It is a well-known fact that oxygen cannot be used to cut cast iron, and it is rather strange that it can be used to drill the mixture of pig iron and slag, which goes to make up a salamander in a blast furnace. It is, however, being successfully accomplished and the results obtained indicate that it is a very much cheaper and quicker method than drilling in the old way.

The accompanying illustration shows a manifold which was developed for this purpose. By means of this manifold, eight standard oxygen tanks are connected together to give a large and continued flow of oxygen. A regulator with two gauges, one to indicate the line pressure, and the other the pressure in the oxygen tanks, are connected at each end of the manifold. To each regulator a line of extra heavy ¼ in. oxygen hose, about 100 feet long, is connected. On each of these hose lines is connected a double length of standard ¼-inch wrought steel pipe, one to replace the other as the first one burns up.

A platform is built 10 or 12 feet above the salamander. A small fire is started with oily waste and the opeartors, working from the platform above, direct the flow of oxygen at the oily waste. Under the influence of the oxygen the waste bursts into violent flame and the surface of the salamander starts to oxidize. The pressure on the oxygen line is increased and the ¼-inch pipe is fed into the hole which starts in the salamander.

In this manner a hole three or four inches in diameter is drilled into the salamander very quickly. In fact, a hole six feet deep has been drilled in 20 minutes with oxygen consumption of only 500 or 600 cubic feet.

It is rather hard to give a scientific explanation for the ability of the oxygen to attack the salamanders so violently when ordinary cast iron is not subject to such an attack. This is probably due in some manner to the rapid oxidization of the wrought steel pipe which is used to direct the oxygen.

The advantage of this means of drilling salamanders is, of course, the extreme speed which can be maintained. We have known of a force of men being able to completely drill a large salamander ready for dynamite in 12 hours' time.

The same means have been employed to cut up smaller salamanders in open hearth furnaces. In this case, the operator is protected with an asbestos suit, gloves, mask, etc., and by properly directing the stream of oxygen the salamanders can be quickly cut into small pieces with comparatively small expense.

Gases Used in Cutting.

Acetylene, natural gas and various compressed or liquified hydro carbons can be used for fuel gas in the oxygen metal cutting process. Acetylene is probably the most widely known, but just now the attention of efficiency and safety departments of steel mills is turned to a new by-product of absorption gasoline plants called butane.

This gas has a very high heat value of about 3,400 Btu to the cubic foot. The gas is claimed to be non-poisonous and not to produce carbon monoxide in combustion. It is not subject to explosions and will not backfire in the tips nor torch. The gas has a gravity about twice that of air and also has an extremely low explosive range. The vapor liquifies at 150 lbs. Recent tests at one of the large steel plants in Chicago demonstrated that the liquid vaporized at several degrees below zero, after the tanks had lain on ice for several hours in weather below zero.

The gas has been thoroughly tested in at least three of the large mills in the Pittsburgh district and in the shops of one of the trunk lines, and it has been found very efficient for general mill, foundry, railroad and structural work. All gases were metered with the same meter on work done by the operators of the plants in which the tests were made, and an average cost at current prices on the gases and oxygen and with time at 60c per hour was struck in arriving at the relative percentage cost of cutting steel with the various gases, as follows: butane, 100 per cent; acetylene, 141 per cent; a hydro carbon gas, 140 per cent. The above figures were based on cutting 100 square feet of metal varying in thickness from 3-16 to 18 inches, each gas being used to cut approximately the same amount of material.

A 42-inch diameter pinion was recently nicked an average of approximately 12 inches all around in a fraction over 37 minutes. A shaft 21 inches in diameter was nicked all around to a depth of approximately 9

(Continued on page 214)

Heating Furnaces and Annealing Furnaces

European Type of Self-Contained Gas Producer and Furnace—Properties and Cost of Blue Water Gas—Combustion Appliances for Using Water Gas.

By W. TRINKS.

PART XV.

THE last installment dealt with the use of producer gas in furnaces. It assumed that the gas was generated in separate producers away from the furnace, but there exists another noteworthy method of using producer gas, namely, the combination of a self-contained furnace and producer, see Fig. 104.

This arrangement is but little used in the United States, but is common in Europe, where it was probably introduced by Siemens. It will be noted that the gas moves by natural draft through the producer and flues. It will also be noted that no steam is introduced into the ash pit (except that small quantity which is caused by hot ashes dropping into the sump). The two conditions go together. The absence of steam causes a fairly hot fire, and a hot but lean gas is produced. By virtue of the close proximity of producer and furnace, most of the sensible heat of the gas is retained. The vertical distance between the depressed producer and the entrance to the furnace forms a stack which moves the air through the fuel bed and moves the producer gas through the flues and into the furnace.

In a producer of this type, that is to say, a producer without steam, the producer gas leaves the fuel bed with a temperature of 1,450 to 1,600 degrees F. With 10 feet difference in level between grate bars of producer and entrance of fuel to furnace, this temperature creates a draft of approximately .11 inches of water. With that draft six to eight pounds of coal can be gasified per square foot of grate surface an hour. Heat can be developed on the grate at a much greater rate, if the coal bed is kept thin, first, because the thin fuel bed offers less resistance, and second, because the much hotter flue gas produces more draft. But a thin fuel bed gets away from the advantages of producer gas and, in their place, introduces all of the disadvantages of direct grate firing, such as burning out of the flues, clinkering, excess oxygen and others. This feature must not be lost sight of. Grates which are too small for the heat requirements of the furnace are very likely to bring the combined producer and furnace into disrepute.

The good features of the self-contained producer and heating furnace are apparent. The distribution of heat in the furnace can be controlled on account of the gaseous nature of the fuel, and yet no separate producer plant is needed. The heater can attend to the producer. But the combination also has bad features. Coal must be wheeled to the furnace, and doing so requires constant labor, or else coal storage right next to the furnace. The composition and the heat value of the gas fluctuate considerably, because the volatile matter in the coal is given off immediately after firing. A deep pit is required in connection with each furnace.

Yet, the self-contained furnace and gas producer will probably find a place in American furnace practice, after oil and natural gas will have risen to prohibitive prices. It is very probable that the ultimate design will have a device for the continuous feeding of coal.

In Fig. 104, air for combustion is preheated in a tile recuperator: the stack effect of the preheated air moves it through the narrow slots of the lower arch, where it meets the gas over a widely distributed area, producing a uniform heat. The furnace in question is of the "Chantraine" type and is built by Smeeton-Wright Furnaces, Ltd., London, England.

Water Gas.

Water gas is generated if steam is blown through glowing carbon. At low temperatures (about 930 degrees F.) carbon dioxide and hydrogen are formed while at high temperatures (1,600 degrees F. or above) carbon monoxide and hydrogen are formed. At the present time no process exists to make gas continuously in the same producer or generator, because the breaking up of the steam into hydrogen and oxygen requires more heat than is given off by the combination of the carbon and the oxygen. The temperature of the fuel bed drops right along while water gas is being made because no process is known to impart heat to the bed of glowing carbon while heat is being abstracted from it by the formation of water gas. In consequence, the process must be intermittent: The fuel is heated to a high incandescence by an air blast, and then the steam is passed through the same generator, until the temperature has been reduced almost to the point below which good gas can no longer be obtained. The process thus calls

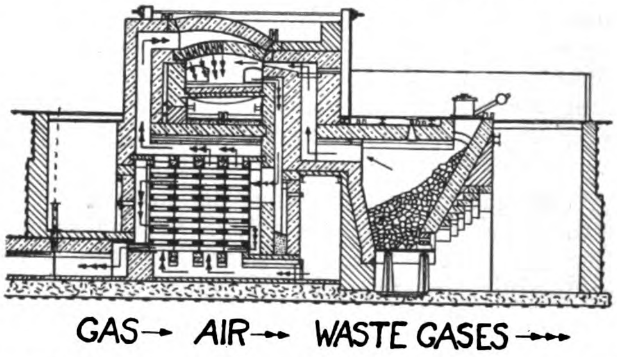


Fig. 104—Another method of using producer gas. The illustratin shows a combination of a self-contained furnace and producer.

for alternate "blows" with air and for "runs" (gas making periods) with steam.

The intermittent feature of the gas making process necessitates either the use of two generators with a small gas holder, or else the use of one generator with a large gas holder. If, in the latter case, the gas is to be used at the average rate at which it is made, the capacity of the holder need not exceed the volume produced during an hour's production.

In either case (one or two generators) the producer works at a constantly falling temperature during the run. The water gas is, for that reason, not of constant composition; the carbon dioxide in the gas increases steadily in amount. In parctice this feature is kept within harmless limits by frequent reversals, but the latter must not be too frequent, because every reversal sweeps some of the lean air gas into the water gas line.

Both the air gas made during the blow and the water gas made during the run, contain a great deal of sensible heat which, if not utilized, would necessarily result in a very low efficiency of the generating process. By using this heat for raising steam for the run, the efficiency is brought up to a much higher value. Water gas apparatus with a waste heat boiler has an efficiency of approximately 70 per cent, provided that it is carefully designed and skillfully operated and that clean fuel is used. Otherwise the efficiency will easily drop down to 50 to 55 per cent.

One of the drawbacks of water gas is that it can be generated only from coke or from hard coal. Before the gas can be used, it travels on its way from the generator to the furnaces, through a washer maintaining a water seal and thence through a scrubber, for cooling the gas and for removing any dirt carried forward from the fuel bed into the holder.

Water gas as used in industrial heating furnaces and annealing furnaces has a high heat value of 302 to 309 Btu per cubic foot (standard conditions) and a specific gravity of .54 to .56. A typical analysis is:

Carbon monoxide, 43.5%; hydrogen, 47.3%; methane, .7%; carbon dioxide, 3.5%; oxygen, .6%; nitrogen, 4.4%.

The gas contains practically no hydrocarbons, and burns, for that reason, with a blue, non-luminous flame. This fact has given it the name "blue" water gas, in contradistinction to carburetted water gas which results from the addition of luminous hydrocarbons and which is used in cities for illuminating purposes. Water gas requires 2.3 volumes of air for complete combustion.

Next to natural gas and coke oven gas (including coal gas) water gas is the richest industrial gas. Its theoretical flame temperature is very high. On account of its non-luminous nature, the flame comes, without any doubt, quite close to the theoretical temperature; the gas contains no hydrocarbons, which break up during the process of combustion and radiate heat away before the combustion is complete.

The gas is clean and can be sent into furnaces through small ports or it can be sent into the furnace premixed with air. In fact, all of the premixers and burners described for natural gas (Part XI) are equally well applicable for water gas. There is, however, this difference: the water gas flame must be made to impinge upon solids to give off heat. These solids may be the material which is to be heated, or, which is much better, refractory material which radiates the absorbed heat back to the steel.

Heat transmission by convection is not nearly as effective as heat transmission by radiation. For this reason, it appears logical to provide in furnaces with water gas heat refractory surface against which the flame plays, of large extent in comparison to the surface of the steel which is to be heated. Agents of the "Surface Combustion Company," who are great advocates of the use of water gas in industrial furnaces, claim that by playing a non-luminous flame against the arch of a furnace roof, just as good heat transmission can be obtained as by direct radiation from a luminous flame. Comparative tests either confirming or else refuting these claims are not avaliable. In the absence of such tests, I would advise to make the heat absorbing and heat radiating refractory surfaces considerably, say two or three times, larger than they need be with natural gas. It should, however, be understood that in many types of furnaces, the refractory surfaces washed over by the flame are large enough in any event, because space has been allowed for flame development. In such cases, there is no need of any difference of furnace design between the use of natural gas and that of water gas.

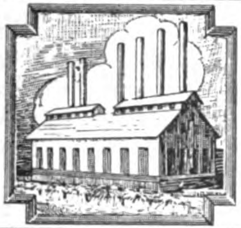
If water gas is used in regenerative furnaces, both the gas and the air can be preheated, because the gas contains no combustions which might be broken up by high temperatures and deposit soot.

One of the principal questions in connection with any fuel is its cost. As in the case of producer gas, no correct data for water gas are available in the shape of a general formula.

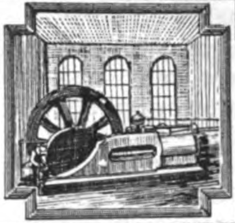
In the absence of a general tabulation, the following may be of use: One pound of excellent coke makes 30 cubic feet of water gas of 280 Btu lower heat value. If the coke contains much ash, this value drops considerably. Each installation requires one or two generators (or multiples thereof), a waste heat boiler, a gas holder, a scrubber, a washer, reversing equipment (valves and pipes) and a gas pump. The gas making requires labor for charging coke, breaking up and pulling clinkers, removing ashes, reversing, admitting the proper amounts of air during the blow and steam during the run. The clinker varies with the fusibility of the ash, and is a very undesirable accompaniment of the present day process of making water gas.

At present (1920) prices the cost of water gas is estimated to range between 10 cents and 30 cents per thousand cubic feet, depending upon price of coke, size of plant and load factor.

From the above data it follows that water gas is not at all suitable for a plant having one or two small furnaces, because the investment cost and the cost of the gas house equipment are prohibitive. The larger the furnace plant the better the installation of water gas equipment pays. If heating for forging or rolling, or annealing are the only requirements, clean producer gas is just as good and is preferred by many.



STEAM POWER DEPARTMENT



Practical Notes on Waste Heat Boilers

Necessity for Fuel Economy Increases Interest in Waste Heat Boilers—Comparison of Direct Fuel and Waste Heat Practice. Proper Number of Passes—Blast Furnace Gas Fired Boilers.

By D. S. JACOBUS and ARTHUR D. PRATT.

THE advantage of an increase in transfer rates in waste heat boilers over that which exists in direct fired boilers is perhaps not generally appreciated In burning fuel under a boiler a temperature is developed greatly in excess of the average waste gas temperature. For comparison of direct fired as against waste heat practice, let us consider a direct fired unit equipped with an underfeed stoker and a waste heat boiler set in connection with oil stills. In the former case the furnace temperature will, with proper stoker operation approach 2,700 degrees F., while in the latter case the temperature of the gases entering the boiler will be approximately 1,000 degrees F.

The importance of the waste heat boiler to the steel industry can be appreciated by the fact that over 210 open hearth furnaces are equipped with such boilers, the total capacity of these furnaces being conservatively 12,000,000 tons per year. In this article the authors present interesting and valuable data as to the economies which can be effected by the intelligent installation and application of waste heat boilers. The authors suggest that it may not be long before there will be laws forcing the conservation of fuel.

In direct fired practice a considerable proportion of the total heat absorbed by a boiler is absorbed through direct radiation to the tubes which are exposed to the radiant heat of the furnace. How great a proportion of the total absorption is accomplished in this manner, is not ordinarily appreciated.

With a reasonably constant furnace temperature the amount of heat absorbed through direct radiation is, within reasonable limits, a constant, irrespective of the capacity developed by an individual boiler. It naturally follows, that as the capacity of a direct fired boiler is increased, the percentage of total absorption through radiation becomes less, as this represents the ratio of the total number of heat units absorbed from the gases, which remains constant, divided by the total heat absorbed by the boiler which increases with capacity. In comparing direct fired with waste heat installations it is necessary because of the low or comparatively low ratings developed in the latter class of work, to consider the direct fired unit operating at a low capacity.

Experiment has shown that for a furnace temperature of 2,700 degrees F. the absorption through direct radiation is, for a four-inch tube spaced on seven inch centers, slightly over the equivalent of 80 pounds of water evaporated per hour from and at 212 degrees F. per lineal foot of tube exposed to direct radiant heat in the furnace, an absorption of some 77,630 Btu per hour. In a 500 hp Babcock & Wilcox boiler, with the baffle arrangement ordinarily offered for underfeed stokers, this evaporation due to absorption through direct radiation would, with the boiler operating at its normal rated capacity, represent approximately 66 per cent of the total heat absorption.

The absorption due to radiation effect varies approximately as the fourth power of the absolute temperature of the radiating medium. On the basis of an absorption through radiation equivalent to an evaporation of 80 pounds per hour from and at 212 degrees per lineal foot of tube in the furnace for a temperature of 2,700 degrees F., the corresponding absorption for a furnace temperature of 1,000 degrees in the case of the waste heat boiler would be approximately 3.65 pounds from and at 212 degrees per hour per lineal foot of tube exposed. If, for the sake of comparison, we assume that both the waste heat boiler and the direct fired unit develop their normal rated capacity, the absorption through direct radiation would be only 3 per cent of the total absorption for the

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Taken from paper entitled "Waste Heat Boilers," read by the authors before the Engineers Society of Western Pennsylvania, February, 1920.

waste heat boiler as compared to 66 per cent for the direct fired boiler. In a 500 hp direct fired boiler operating at its normal rated capacity the absorption through convection will be then equivalent to 170 hp. If the 500 hp waste heat boiler is to develop its normal rated capacity the absorption through convection must be equivalent to 485 hp.

The temperature of the gases out of the radiant heat zone in the direct fired boiler will be somewhat higher than the temperature of the gases entering the waste heat boiler, the relative temperature with the direct fired unit and waste heat boiler both developing the rated capacity being approximately 1,200 and 1,000 degrees respectively. If the two units are operated at the same pressure, and the gases are cooled to the same ultimate temperature, we will have relative average temperature differences of approximately 460 degrees and 360 degrees. The total absorption through convection is represented approximately by the product of the transfer rate, the heating surface and the range of temperature difference. To develop the capacities indicated above through convection it would be necessary to obtain transfer rates as follows:

Direct Fired

$$R \times 5{,}000 \times 460 = 170 \times 33{,}477 \qquad R = 2.47$$

Waste Heat

$$R \times 5{,}000 \times 360 = 485 \times 33{,}477 \qquad R = 7.02$$

In other words, if each of the two units is to develop its rated capacity, it would be necessary in the case of the waste heat boiler to arrange the heating surface in such a manner as to give a transfer rate over three times as great as that in the direct fired unit. This comparison is an extreme case which has been used to indicate the necessity of high gas velocities where the gases are of a low temperature; conclusion should not be drawn from it respecting the effect of the absorption of radiant heat on the efficiency of a direct fired unit as other elements enter into the problem.

The heat absorption, or heat transfer rate, is dependent upon the gas velocity, and not upon the number of passes except insofar as the number of passes affect the velocity. For equal gas weights the velocity is the prime factor affecting the transfer rate, for at any velocity so far used in modern waste heat work, the effect of the temperature of the gas is small as compared with velocity. Naturally for a given transfer rate the greater the temperature difference the greater the total heat absorption, but the temperature for the gas velocities employed has so small an effect on the rate itself that any difference in the rate can be neglected.

First assume the heating surface of a water tube boiler with horizontally inclined tubes arranged to give the gases four passes over it. If the boiler were say 18 tubes high a gas particle would strike the tubes 4x18, or 72 times.

Again take this same amount of surface arranged to give three passes of the gases in a boiler of a given width. In order to obtain the same gas velocity and the heat transfer corresponding to such velocity in the three-pass unit it would be necessary to reduce the length of the tubes 25 per cent below that employed in the four pass unit, and the equivalent amount of surface would be added in height. The three pass unit would be 24 tubes high to give the same heating surface. In such a boiler a gas particle would again strike the tubes 3x24, or 72 times.

Carrying the comparison to an extreme case, if the same amount of heating surface were arranged to give a single pass of the gases, still maintaining the same gas velocity and transfer rate resulting from such velocity, it would be necessary to shorten the tubes 75 per cent. This would result in a unit 72 tubes high, and a particle of gas would naturally strike the tubes 72 times as in the other cases. Such an arrangement of heating surface would of course be impracticable, but is described to indicate the principle involved.

The heat transfer rate would be the same for the three cases considered, that is, for 4, 3 or a single pass, whereas the frictional resistance to the flow of the gases, or the draft drop, would be greater, the greater the number of passes on account of the added resistance due to changing the direction of flow of the gases in the different passes.

Number of Passes.

Because of the flexibility of design through varying the arrangement and the amount of heating surface by changing the width and height of the boiler and the length of the tubes, it is theoretically possible to give the gases any desired number of passes over the heating surface and still maintain the gas velocity which will give the greatest commercial return. Under such conditions the proper number of passes to employ in waste heat work becomes a question depending upon commercial rather than engineering factors, and these should be given consideration in each specific installation.

There is the question of cost, though because of the relatively large return on the investment with this class of apparatus, this is usually not of primary importance. A single pass boiler without baffles is the simplest unit that can be offered. With a single pass boiler, however, in order to maintain a velocity resulting in adequate transfer rates, it is ordinarily necessary to make use of short tubes, which leads to a construction of relatively high cost.

A second consideration in the proper number of passes to be offered is that of the point of removal of gases from the boiler setting. For any waste heat boiler where the gases enter beneath the tubes at a point corresponding to the furnace in ordinary direct fired practice, where the number of passes is made odd, i.e., 1, 3, or 5, the gases must be removed from the setting at or near the top of the boiler. Where the number of passes is even, the gases must be taken from the bottom and at the rear of the boiler.

The best arrangement to use in most cases is three passes. Where an overhead connection is desired fan supports and platforms are provided. Where it is desired to place the fan and its drive on the floor an easy connection can be made through the rear water circulators to the fan.

The most important factor, in the determination of the proper number of passes to be offered in waste heat work, is that of draft. The draft loss through a water tube boiler is a function of two factors—the loss due to frictional resistance to the gases in their passage over the tubes, and the loss due to the making of the turns over the baffles. In any upward pass of the gases there is a stack effect, due to the pass itself, which tends to offset the loss due to friction, and it is no uncommon occurrence in high temperature direct-fired practice to find a greater draft suction at the bottom than at the top of an up-pass of a boiler. In a downward pass of the gases on the other hand, there is a negative head to be overcome in addition to friction.

In order to recover the major portion of the power used for the fan drive through utilization of the heat in the exhaust, it is almost universal practice in waste heat work to use a steam turbine drive for the induced draft fan. Experience has shown that with the gas velocities best adapted for this class of work, the exhaust from the fan turbine when producing draft sufficient to overcome the total resistance through a properly designed three-pass boiler unit and giving the required draft at the outlet of the primary furnace, is just about the amount required to heat the feed water entering the waste heat boiler to 212 degrees F. While the amount of heat recovered in this manner will of course vary with the gas temperature, the fan and turbine efficiency, and the class of primary furnace, the statement above may be accepted as generally correct.

Single Pass Waste Heat Boilers.

Single pass waste heat boilers without any induced draft apparatus are the simplest that can be employed and, in fact, it is this design that was probably among the first of the water tube boilers used in waste heat work. The early installations, however, were made of a low draft resistance in order not to interfere with the operation of the primary furnace.

There is a considerable field for the single pass, natural draft, waste heat boiler even under modern conditions. In plants where such boilers are applicable the gas temperatures are high, approaching those of direct fired practice, and greatly in excess of the temperatures for which our modern design of waste heat boilers were developed. This statement is not to be taken as indicating that high gas temperature alone, without taking into consideration the other factors involved, makes the installation of a single pass advisable rather than a multiple pass unit, but to indicate the limitation of the field of usefulness of the single pass unit.

The single pass unit can be successfully used only in connection with a furnace requiring a low draft. In some instances, such as in a puddling furnace, the heating surface can be so arranged that the boiler itself serves to an extent as a stack and in serving as such the available draft from a given stack, although less than if no boiler were installed, will, when added to the stack effect of the boiler provide enough draft for operating the furnace. If, on the other hand, we consider a primary furnace from which the gases leave at low temperatures and which requires a greater amount of draft for proper operation, such as an open hearth steel furnace, the cooling effect due to the installation of boiler heating surface, even in a single pass low gas velocity unit, would reduce the available draft to a point where the furnace operation would not be possible. In open hearth steel practice a draft of 1.5" to 1.7" is required at the checkers. Where no waste heat boiler is installed, with a gas temperature available of, say, 1,100 to 1,200 degrees F., a stack 160 to 175 feet high will produce the necessary draft. If, however, a waste heat boiler is installed which would cool the gases to say 600 degrees, the stack which would give 1.6" draft with a gas temperature of 1,200 degrees would give probably less than 1" with a temperature of 600 degrees, which would be too low for operating the furnace even should a single pass boiler be employed. If we allow a total draft loss including the loss due to a single pass unit of .75" between checkers and stack, the heights in order to secure proper furnace operation would have to be about 400 feet. Under such conditions it is evident that with open hearth and similar furnaces waste heat boilers, either single or multiple pass, cannot be installed except in connection with induced draft.

A single pass boiler may be used to advantage where a low weight of gas is available, as where the gas weight is small and the total corresponding return low, the expense of an induced draft apparatus in addition to that of the boiler may not be warranted. This applies particularly to plants where, though the gas weights are low, the temperatures are high.

A single pass rather than a multiple pass boiler is sometimes the best to install in the case of an isolated plant where there is no outlet for the power developed except for use at the plant. In such a case if the single pass natural draft boiler will cool the gases to a point where the steam produced will meet the total requirements for the plant there is obviously no necessity or object in going to the expense of a more complicated multiple pass unit with its induced draft apparatus. Naturally in this case the draft requirements of the primary furnace must be such that a single pass natural draft unit may be satisfactorily installed.

Blast Furnace Gas Firing.

There is a development not strictly dealing with the recovery of waste heat that may be considered in connection with water heating boilers, which is the use of our modern waste heat boilers for direct fired practice. In the burning of a fuel under a boiler, if high furnace temperatures are developed and sufficient heating surface is exposed to radiant heat in the furnace, the absorption due to direct radiation is ordinarily a large proportion of the whole. With fuels such as blast furnace gas, where it is neither practicable nor possible to obtain high furnace temperatures, to develop the same capacity from a given boiler, the amount of heat absorbed through convection compared to that absorbed through radiation must be greater than in the case of the high furnace temperature unit. In this case it is advantageous to apply the principles of our modern waste heat boiler design.

While furnace temperatures of 2,200 or 2,300 degrees are theoretically obtainable with blast furnace gas, it is probable that even with the best design of burners the temperatures do not average over 2,000 degrees. With this furnace temperature, the absorption through radiation will be less than 40 per cent of that absorbed through radiation with a furnace temperature of 2,700 degrees F. If, therefore, the total return from blast furnace gas is to be made comparable with that to be expected in high temperature work, it becomes necessary to increase the percentage of total absorption through convection.

Until the past few years blast furnace gas was regarded as more or less of a waste product. No particular effort was made to develop an efficient method of burning the gas and as in the case of early waste heat work any steam generated through its use was simply accepted as "something for nothing." As indicative of the efficiencies secured with blast furnace gas, quotations from a paper presented before the American Iron and Steel Institute in 1915, by Mr. Ambrose N. Diehl, are of interest:

"The average efficiency of a blast furnace plant, using common burners and operating without the aid of technical supervision, is not over 50 per cent, and frequently much lower."

And:

"Of a total of 60 blast furnaces in the corporation under observance the tests and information from the operators indicates a practice of not exceeding 55 per cent. The increase of 10 per cent probably possible with improved conditions will show a yearly saving of $1,500,000."

In line with other movements toward general conservation, steel mill operators began to realize that any increase in the efficiency with which they could burn blast furnace gas would result in a decrease in the consumption of a higher cost fuel in other portions of the plant.

Assuming a furnace of proper form and volume, the logical starting point, in the development of any improved method of burning the fuel in question, was in the design of the gas burners. The designers and manufacturers of blast furnace gas burners developed their product to a state where they were able to burn this fuel more efficiently than in the older practice. For combustion completed within the furnace the conditions were similar in all essential details to those under which our waste heat boilers had given eminently successful results. The gas temperatures entering the heating surface were no higher than in bee-hive coke oven and in certain classes of heating furnace waste heat work. The gas weight in common with waste heat practice, was higher than for coal firing, for even with a minimum of excess air the weight of products of combustion for blast furnace gas is some 75 or 80 pounds per boiler hp developed as against 45 or 50 pounds in the case of underfeed stokers. The furnace volume and length of gas travel are the important factors. The furnace volume measured in cubic feet per rated boiler hp, is some three times as great as the volume formerly believed to be ample in this class of work. The furnace arrangement is in general designed to secure a maximum furnace temperature rather than expose any large proportion of the tube surface to the action of the radiant heat. These modern units operating at about their rated capacity are showing efficiencies of some 76 per cent. When operating at 200 per cent of normal rating the efficiencies are approximately 73 per cent.

Rate of Steam Flow to Regulate Boiler

New Regulating Apparatus Designed to Control Combustion Primarily From Variations in the Rate of Steam Flow—Reciprocating Valve Used to Control Steam Supply to Stoker Drive.

THE economical use of fuel is practically a new problem in America, particularly in the steel industry. With an almost unlimited supply available at low prices it was natural that little attention would be given to economy in the use of this fuel.

During the last five years a complete change has taken place in the fuel situation. We find that in spite of the almost unlimited quantity available, it requires labor to perform the necessary mining operations, and transportation facilities must be provided to deliver this fuel from the mines to the point of consumption. The present abnormal conditions have resulted in a great increase in the price of coal and at times it is not available at any price. These conditions have given rise to a situation, which emphasizes the importance of economy in the use of fuel and have made this one of the most important problems with which the engineering profession must deal.

Volumes have been written on the chemistry of combustion and the conditions required for the most economical use of fuel are thoroughly understood. Mechanical apparatus has been developed to a high degree of perfection, until practically all the work around a boiler plant is done by mechanical means. In spite of these improvements, however, and the thorough knowledge regarding the conditions necessary for efficient combustion, the great majority of the boiler plants continue to waste from 10 to 50 per cent of the coal they buy. An analysis of these losses will show that by far the greatest is due to improper combustion in the boiler furnaces, and this in turn is caused by improper regulation of the fuel and air supply.

The load on any boiler is subject to variations depending on the nature of the plant, but in no case does an absolutely constant load exist. In order to take care of the variations in load the fireman adjusts the amount of fuel and air supplied to his furnaces in accordance with the pressure of steam. If the steam pressure starts to drop he increases the fuel and air supply, and if the pressure starts to increase he reduces the fuel and air supply. The difficulties are encountered in making these adjustments. First, when a change in the rate of fuel feed has been made it is difficult to make the corresponding change in rate of air supply so as to maintain the correct ratio between fuel and air. In the second place, it is difficult to determine in advance just how much of an adjustment should be made. The steam pressure may be dropping, due to a small increase in load or to a large increase, and the only way this can be determined is to watch the pressure gage and see how rapidly the pressure falls. Coal and air are fed to a furnace to generate steam measured in weight of water

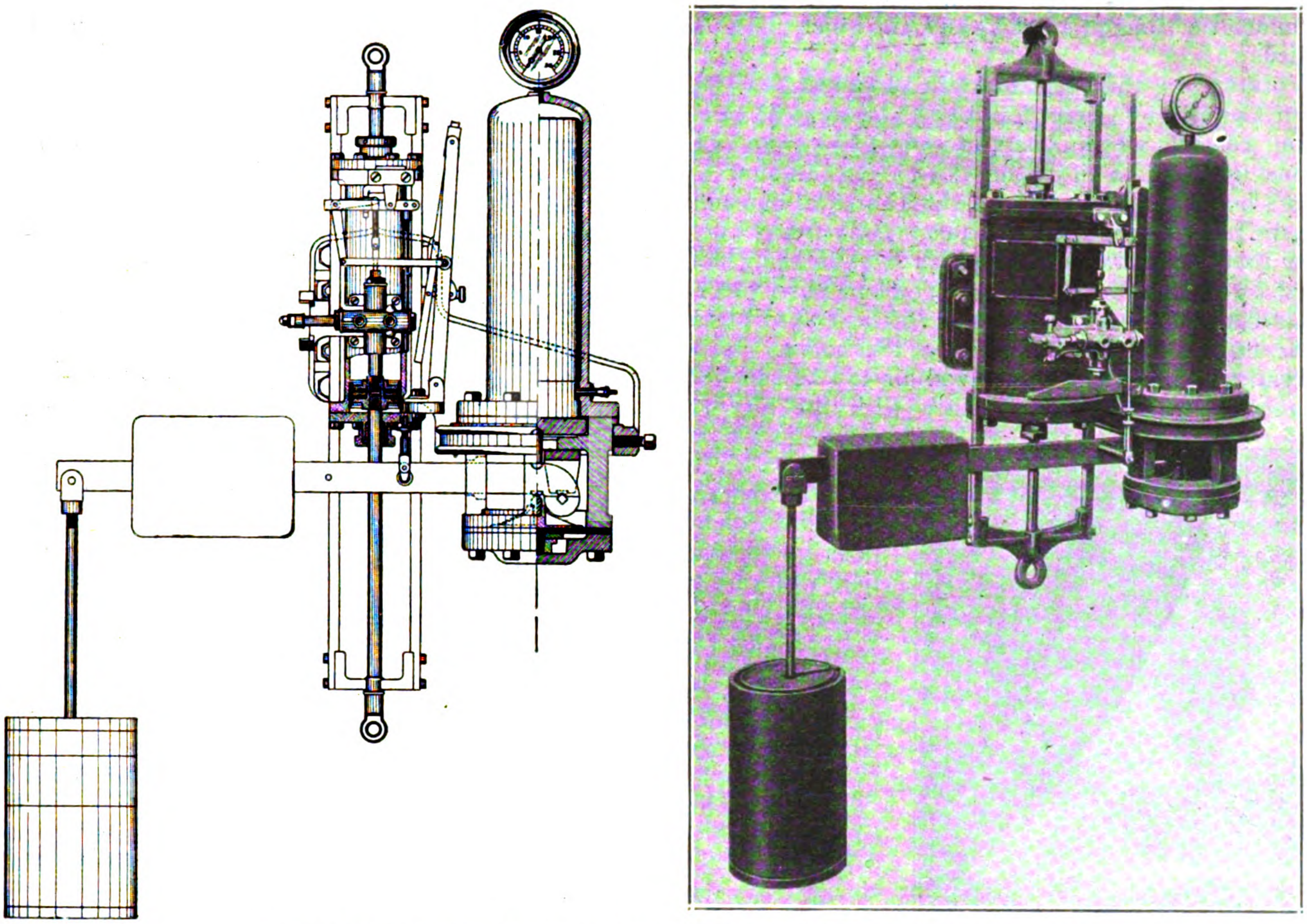
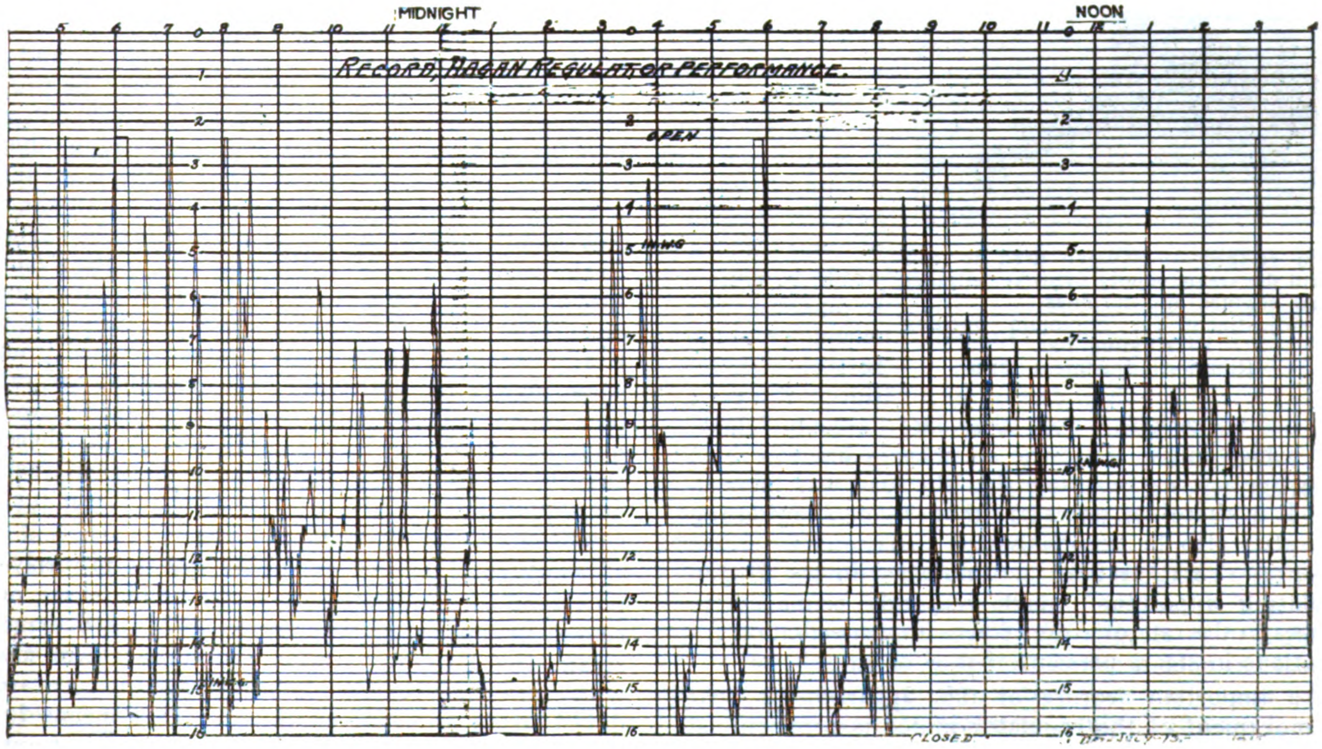


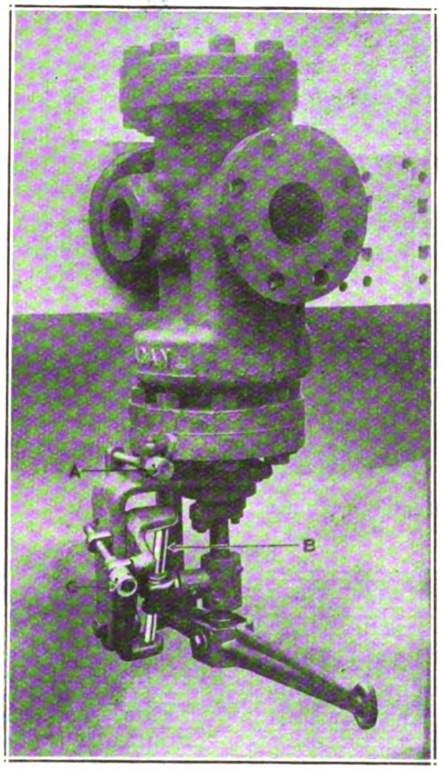
Illustration showing section and exterior view of Hagan Master Regulator.



This 24-hour chart shows the record of the movements of the Hagan Master Regulator controlling the fuel and air supply in a plant which was subject to wide fluctuations in load.

evaporated. It is apparent therefore, that the weight of water evaporated rather than the boiler pressure determines the amount of coal and air which must be supplied.

Working on this principal the engineers of the Hagan Corporation have developed a system of combustion control which operates primarily from variations in the rate of steam flow. The amount of steam a boiler will deliver for a short interval depends upon the rate at which steam is taken away from boiler rather than upon the rate at which heat is being absorbed by the boiler. The rate of steam flow, therefore, is determined not by the rate of heat absorption by the boiler, but by the load on the boiler. It is apparent, therefore, that if fuel and air can be supplied to a boiler furnace in accordance with the rate at which steam is being taken from the boiler, the ideal conditions of operation will result. A boiler will respond almost instantaneously to a change in fuel and air supply, and if these adjustments can be made immediately upon any change in the demand for steam, the tendency to variations in pressure will be overcome. If ideal conditions could be maintained at all times, combustion control of this kind would be entirely practical, and would give the best possible results. There are many variables to take into account, however, which might cause the steam pressure to rise in the boiler at the same time that the load was increasing. It is, therefore, necessary that the ideal regulating apparatus also be responsive to variations in steam pressure. This has been accomplished in the Hagan regulating apparatus, which responds primarily to changes in the rate of steam flow with compensation for variations in steam pressure if they occur.



Roto reciprocating valve used to control the steam supply to stoker engines, fan engines and turbines.
A—Adjustment for minimum opening.
B—Angling bar.
C—Rotation adjustment screw.

An important feature of this apparatus is that the movement of the regulator motor is proportional to the variations of steam flow. There is no tendency for the mechanism to hunt from one extreme position to the other which has been a common fault of combustion regulating apparatus in the past. The accompanying chart shows a 24-hour record of the movements of a Hagan Master Regulator controlling the fuel and air supply in a plant which was subject to wide fluctuations in load. It will be observed that the regulator seldom went to either extreme position, and that most of the adjustments in fuel and air supply were of small amount. Large adjustments occur daily only when there were large variations in steam demand.

The regulating apparatus can be adjusted to make it sensitive to a variation of 1/16-inch of mercury charge in differential pressure. This sensitive operation is desirable for certain plants, but would be entirely impractical in others. The apparatus is, therefore, designed so that adjustments of the sensitiveness can be made, and the desired degree of sensitiveness which will best meet any set or load conditions can readily be secured after the apparatus has been put into operation. The Hagan Master Controller is designed to take a stroke of 10 inches and is made in sizes to suit plant conditions. In the case of natural draft stokers, the adjustment of the boiler dampers and control of the stoker speed are so proportioned that the rate of fuel and air supply will be correct for all rates of combustion. In the case of forced draft stokers, the forced draft fans and the stoker drive are controlled, and if desired the boiler dampers can be handled also.

An important part of this control apparatus is the Roto reciprocating valve, used to control the steam supply to stoker engines, fan engines and turbines. The power required to drive the average stoker is very small and a valve which is capable of accurate adjustment must be employed. The Hagan Roto reciprocating valve is of the piston type, and has a combined motion of reciprocation and rotation. The minimum opening of the valve can be adjusted to give the desired minimum speed of engine or turbine, and after this minimum has been established it can be properly set and will not be affected by any adjustment which may be made for rate of opening or maximum opening. The reciprocating movement of the valves is secured by a connection from the master regulator and the rotation is adjusted by means of an angling bar attached to the valve body. By adjusting this angling bar, the rate of valve opening can be regulated to suit an engine or turbine driving a stoker where the torque is practically constant, while another valve operated from the same master regulator can be so set that the rate of port opening corresponds to the increased power required to drive the forced draft fan. It is, therefore, easy to secure the correct relation between fuel and air supply for any given rating, and uniform fuel bed conditions therefore result.

Since the fuel and air supply can be properly proportioned to one another and can be increased or deceased in unison, in accordance with the demand for steam, the extreme variations in furnace temperature which ordinarily exists in the average furnace are reduced to an absolute minimum. This means longer life of furnace brick work, less maintenance to stoker parts, and more uniform circulation of the water in the boiler, which is an important factor in preventing the burning out of tubes.

Notes on Boiler Feed Water Treatment

Thermal Losses Due to Scale—Impurities Usually Encountered and Some Suggestions as to Methods for Removing Them—Flexibility of Treatment to Meet Varying Conditions Desirable.

By THOS. G. ESTEP.

THE tendency in the modern steam plant towards higher steam pressures and greater boiler capacities has made it necessary to give a great deal of consideration to the problem of securing a boiler feed water that can be used safely and satisfactorily under the new conditions.

There is no doubt but that the thermal losses due to scale have been greatly exaggerated and due to this exaggeration, very often more money has been spent in keeping tubes clean than would be lost by a moderate amount of scale. Without having any definite data at hand, it is the writer's opinion that a boiler feed water that requires frequent blowing down will be more wasteful than one that produces scale in small quantities.

The results from a great many tests show that it is impossible to state thermal losses due to scale in terms of the thickness. Probably the most complete tests that we have on this subject are those made at the University of Illinois and they illustrate the great variation in thermal conductivity of scale. For example, one test showed a decrease in conductivity of 9.1 per cent for a scale .02 of an inch thick and another a decrease of only 6.75 per cent for a scale .13 of an inch thick, both scales having the same appearance. It is quite evident that the decrease in thermal conductivity due to scale depends upon thickness, texture and chemical composition.

With the great increase lately in the cost of fuel, the losses from scale are no doubt important but the increase in boiler capacity made possible by the modern stoker has made the elimination of scale an absolute necessity if continuous and safe operation is to result. A boiler containing even a thin layer of scale cannot be operated at 300 to 400 per cent of rating without tube failures and large repair bills. At the high ratings, not only must a greater amount of heat be absorbed in a given time but the higher velocity of steam particles is very favorable to both incrustation and corrosion.

Since water is so nearly a universal solvent, it is very rarely that a natural water can be found in sufficient quantities that will be free from objectionable impurities. This being the case, some form of boiler feed water treatment must become an integral part of the modern steam power plant.

The impurities usually encountered that are objectionable are the carbonates and sulphates of lime and magnesia, some of the chlorides, particularly magnesium chloride, the alkali salts, sewage and organic matter, clay and silicon in suspension.

The carbonates of lime and magnesia are held in solution by an excess of carbon dioxide and hence, will be thrown out of solution by driving off the carbon dioxide by heating. If feed water is heated in an open heater to 212 degrees F., practically all of the calcium and magnesium carbonate will be precipitated and the precipitate passing into the boiler comes in contact with other solids and forms a scale on the heating surfaces.

If the water could be carefully filtered after leaving the heater, no trouble would be experienced from carbonate scale but these salts are very difficult to separate by filtration and this method is not practicable. Sedimentation will not answer because these salts settle very slowly, calcium carbonate settling at the rate of about two inches per hour. It is evident then that heating the feed water will not bring much relief from the carbonate impurities.

The sulphates of lime and magnesia are soluable in cold water but almost insoluable in water at 284 degrees F. or above so that these salts will be thrown out at the temperature attained in the boiler. These two salts produce a very hard impervious scale and are the most objectionable of the incrusting solids. This scale would be soluable in cold water but is practically insoluable at the high temperatures obtained in the boiler and hence, grows continually worse.

The magnesium chlorides and sulphates will cause corrosion and pitting. This must be corrected by chemical treatment.

The sodium and potassium salts are supposed to cause foaming but there is a great deal of evidence that foaming is caused by suspended matter rather than salts in solution. Since boiler scale will be broken up by these salts, and remain in suspension, it is this that causes foaming and not the salts themselves. Whether this is correct or not has not been definitely established. It is true that in water treating plants using soda ash, if this chemical is used in excess, foaming will result and the immediate remedy then is blowing down and filling again. If the water in the gauge glass has a muddy appearance, it is a pretty sure sign that the soda ash is in excess.

Sewage and suspended matter can usually be taken care of by filtration, sometimes a coagulant is necessary. Oil and organic matter can be removed from the boiler to a certain extent by a surface blowoff.

The high steam pressures that are now in use in some plants and planned for in others make the use of economizers a necessity if good economy is to be secured. This need is also accentuated by the higher stack temperature resulting from higher ratings.

To use an economizer successfully the gases must not be cooled below their dew point. This means that the feed water should be heated to 210 degrees F. or higher before reaching the economizer. If this is done and there are any carbonates in the water, these carbonates will form hard scale in the economizer tubes and soon lower its efficiency. As the temperature is raised in the economizer some of the sulphates will also be thrown out and add to the trouble.

(Continued on page 214)

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PRODUCTION TOPICS

CORRECTION OF ERROR AND ADDITIONAL APPLICATIONS OF CALORIZING.

On page 109 of the January issue of THE BLAST FURNACE AND STEEL PLANT an illustration was shown which is again reproduced on this page. In the article appearing in that issue a caption was placed under the illustration, which read "Calorized Annealing Boxes." This was an error. The illustration was intended to show the results which calorizing could prevent. The caption should have read, as follows "Annealing boxes burned to a crisp and condemned as scrap. Calorizing would prevent this." The cut referred to is shown in Fig. 1 on this page.

As explained in the previous article the purpose of the calorizing process is to prevent oxidation of metals which are subject to high temperatures. It is of interest to draw attention to some of the more important industrial uses to which this process has been successfully applied.

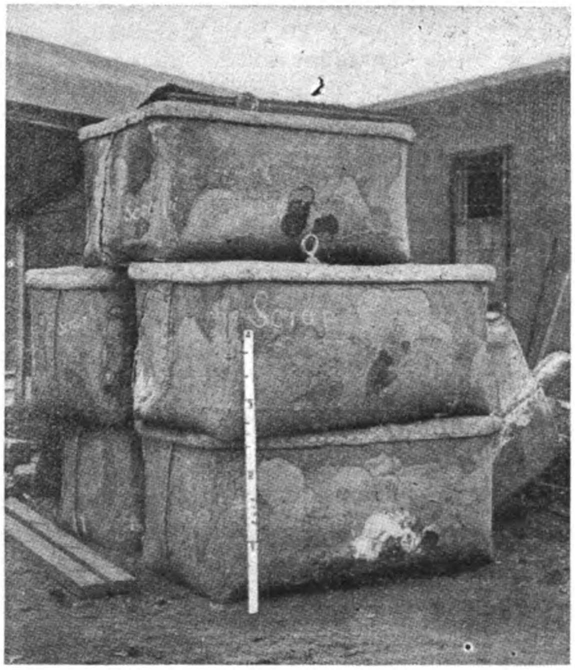

Fig. 1—Nest of annealing boxes burned to a crisp and condemned as scrap. Calorizing would prevent it.

Calorizing has been put to a great variety of uses including its application to retorts, carbonizing and annealing boxes, pyrometer tubes furnace castings, tubes for preheating air, flue lining, pipe for conveying molten glass, torch nozzles, blast furnace, tuyeres, oil crackers, soot blower units, lead pots, valve and piston heads for Diesel engines, preheating coils for oil burners, hot bulbs for oil engines, etc.

Carbonizing and annealing boxes and a variety of heat-treating equipment of this nature has been successfully calorized. The calorization prolonging its life from three to 30 times.

Calorized Pipe and Tubes for Heat-Treatment Processes and for Boilers, Condensers and Economizers.

It is entirely feasible to make up calorized coils of pipe and a wide variety of shapes, lengths, and sizes. Straight pipe ¼ inch to 18 inches diameter has been calorized in lengths up to 20 feet.

Calorized steel is particularly adapted to pyrometer protection tubes because of the high temperature to which they are exposed. Not only is it cheaper than any of the chrome steel alloys which have at times been offered for this purpose, but it possesses other advantages as follows: Greater uniformity of structure of material due to natural superiority wrought steel tube over a cast tube; non-porosity; decrease in the "lag" on pyrometer readings; special shapes can be bent from standard tubing either before or after calorizing, eliminating the expense of special castings.

Furnaces, Ovens, Kilns and Retorts.

Many furnaces, kilns ovens and retorts employed in various manufacturing processes were originally made of iron or steel. This metal had a limited heat-resisting quality and was reduced to scrap in a short time. It was frequently replaced, but its life was short because of the excessively high temperatures and the repeated performance continuing indefinitely. As the price of the metals increased, the use of the other materials was considered by engineers in an effort to reduce costs. They built these furnaces from firebrick and various refractory materials. In a great many instances these materials were used at a loss of 25 per cent to 75 per cent in efficiency, but were adopted because the repair costs on iron and steel were prohibitive. Calorizing can be applied to metal furnace linings, baffle plates, etc., the cost of these calorized plates per unit of service being in a great many cases much less than that of refractory materials. There is an unlimited field for calorizing as applied to equipment of this nature.

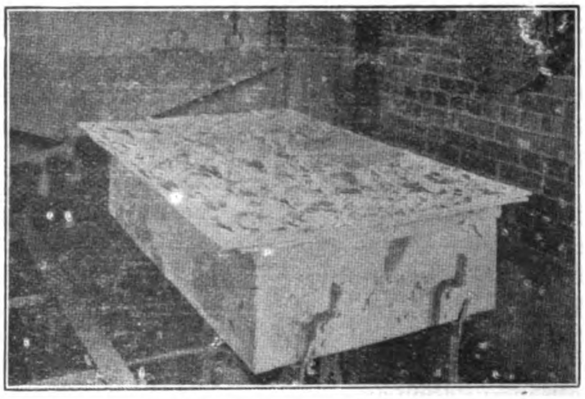

Fig. 2—A small portion was cut from the cover of this annealing box, calorized and welded back. It was then tested. The result of the test is clearly shown.

Heat-Treating Equipment.

Perhaps the largest and most easily developed field for calorizing lies in its application to the various pots, boxes, tubes, retorts, and special equipment employed in the many heat-treating processes. A large quantity of the above mentioned articles have been successfully calorized, their average life being over eight times that of the uncalorized equipment, resulting in a great saving by the use of calorized equipment.

History of Development.

The General Electric Company of Schenectady, New York, evolved and developed the best present known method of preventing oxidation at high temperatures. This process, known as calorizing, was used by them with great success in connection with their manufacture of electrical heating

PRODUCTION TOPICS

devices. The Diamond Power Specialty Company of Detroit, Mich., was attracted to calorizing, as a means of preventing the oxidation of their blower units which were placed in the high temperature areas of boilers. This concern applied the new process to their product with most successful and gratifying results.

A plant was established in Detroit to carry on the calorizing of the Diamond Power Specialty Company's requirements, and many prominent metallurgists, chemists and men connected with large mechanical industries visited the Detroit plant to investigate the new process. This resulted in such a demand for the calorizing of outside requirements, that the Calorizing Corporation of America was eventually formed, and furnace equipment installed to care for the commercial business.

The application of the calorizing process to the requirements of the many varied industries of the country called for much investigative development, and over $100,000 was spent in constructing and determining the proper furnaces to meet commercial needs. The capacities of the furnace retorts were increased until at present the largest retorts approximate 24 feet in length. Requirements for some of the largest industries of the country have been calorized, and the life of the calorized parts increased from 10 to 30 times, according to the conditions of temperature and use. Parts made of cast iron, black or wrought iron, malleable steel, nickel-steel, nickel, copper, brass and bronze may be calorized very satisfactorily.

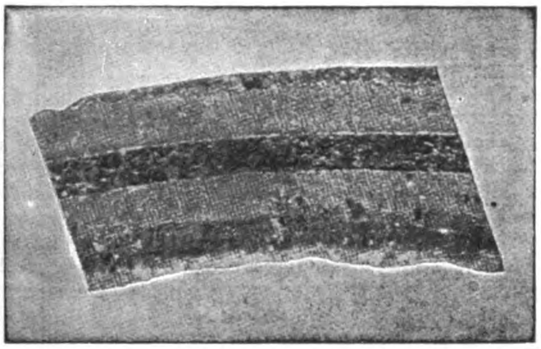

Fig. 3—Micro-photograph showing cross-section of calorized steel tubing.

Process of Calorizing.

The process of calorizing incorporates the impregnation of the surface metal of the treated parts with pure aluminum, and this impregnation penetrates to a depth of one-fortieth to one-fiftieth of an inch for usual requirements. However, by extending the time of the processing this impregnation can be increased appreciably. So long as the homogeneous alloy surface resulting from the calorizing, is not broken up by drilling or otherwise machining, resistance to oxidation is afforded in combustion temperatures ranging up to 1,800 degrees F. The calorized surface is comparatively smooth, and the process does not change the physical characteristics of the metal, excepting to accomplish a slight anneal, resulting from the temperature of the furnaces during the process. The expansion and contraction, and the tensile strength of the metals are the same as before being calorized.

In addition to resisting oxidation in high temperatures, calorized metal will resist the action of certain acids and gases not encountered in combustion. Calorizing offers a large application to equipment and production parts exposed to oxidation from heat, and solves many mechanical problems, as well as establishing a large economic value. The economy in the use of calorized metal parts is not only represented in the actual value of the parts that have to be replaced, but also in the large labor-cost involved in the replacement, and the further very important expense of laying up of equipment and the loss of production. Calorizing is applicable to parts and equipment used by furnace builders oil refiners, pyrometer users and manufacturers, and the makers of furnace parts, burners, engine exhaust valves, superheaters, vaporizers, economizers, carbonizing and annealing boxes, and a range of production too numerous to comprehensively list.

New Plants to Be Built.

At the present time the plant in Detroit is the only one of its kind in the world, but within the next 30 days a plant will be established at Hartford, Conn., and it is intended that eventually plants will be established throughout the country to care for the requirements of the various territories. The Calorizing Corporation of America operates as prime licensee under the patents owned by the General Electric Company, and has the right to sublicense the process to responsible concerns whose requirements warrant the installation of a calorizing department. Arrangements will also be entered into on a license basis with interests desiring to establish plants for the calorizing of general commercial requirements. With the past accomplishment in this line of work, and the tremendous field and opportunity offered for future development, calorizing is certain to play a large part in the use of metals among the industries where oxidation is experienced in high temperatures.

Fig. 4—Two pieces of extra heavy wrought iron pipe the upper calorized the lower uncalorized, after subjection to the sulphur dioxide test.

Inasmuch as this process is relatively new there are doubtless many possible applications of calorized metal which have as yet not been considered. The Calorizing Corporation of America, Detroit, Mich., has issued a very interesting booklet entitled "The Protection of Metals From Oxidation at High Temperatures" by W. E. Ruder, which is of exceptional value to anyone interested in this subject.

In connection with a program calling for about $15,000,000 for new construction work, the Cambria Steel Company, Johnstown, Pa., is planning for a number of immediate improvements at its works. A new plant will be constructed at the Franklin works at a cost of about $1,750,000, to be used for the manufacture of tank cars. A large number of tools will be installed. At its Johnstown plant the company will build two large boiler plants with capacity of about 12,000 hp. and estimated to cost with equipment, close to $2,000,000. At the Franklin works it is proposed to use about 8,000 hp of this total output, and at the Cambria works the other 4,000 hp. The plants will be equipped with watertube boilers, superheaters, and considerable auxiliary operating equipment.

PRODUCTION TOPICS

IRON AND STEEL NEWS OF THE BIRMINGHAM DISTRICT.

Smaller manufacturing companies with capitalization ranging between $50,000 and $250,000 are in the course of organization in the Birmingham district and plants of more or less size giving employment to from 10 to 50 and even 100 men in each will be constructed by each concern. These industries will be a fact before middle summer, announcements to be made in the near future of several corporations being formed to take up manufacture at once. The industries will be located in the city and just outside the city limits. Negotiations are under way in a number of instances for the sites while in other cases deeds are being drawn up. Until all papers have been drawn up announcements will be withheld but the list includes plants using iron and steel, woodworking industries, etc.

All plans are now complete for the starting up of the plant of the Birmingham Coke and By-Products Company on February 25, the first coke to be turned out on that date. Announcement is made that contracts have been made for the disposition of all of the products of the industry including coke, sulphate of ammonia, benzol and other things.

The gas will be furnished to the National Cast Iron Pipe Company, a rivet and foundry plant and other industries at Tarrant City and Boyles, and inducements are being offered other smaller industries for that vicinity. The expectations are that when once the 50 by-product coke ovens are in operation there will be no letup in the activities for an indefinite period. The coal is to be brought from the Majestic and Bradford mines and already arrangements are being made for stocking bins so that there will be no trouble when once the plant is going.

Railroad representatives report shipments of products of the Birmingham district to far off points, cast iron pipe being shipped to the extreme Western section of the country as well as to the Northwest; pig iron movements are to the New England states, as well as to the Northwest; sanitary pipe is moving from the Birmingham district in various directions while steel wire and wire products are being destined to the Southeast for export and elsewhere, much long haulage stuff being offered by manufacturing concerns here. For that reason railroads with connections with the initial roads of this district are to establish agencies here when the railroads are returned to private ownership in order that the business can be solicited.

Thousands of tons of cast iron pipe will be shipped this year into the West and Northwest from this region. Pig iron sales beyond Chicago will aggregate considerable. Other products of this district are being sold which will have to be hauled many miles. Even coke is to be moved in quantity to the Southwest.

Throughout the district there is much interest being manifested in the announcements being looked for from the Tennessee Coal, Iron & Railroad Co., or rather the United States Steel Corporation the parent organization, as to development plans for the present year. It is known that consideration has been given looking to further development at Fairfield, the nature of which is not yet to be given publicity.

The various industries of the Birmingham district are operating on what might be termed full capacities, that is the iron and steel industries and the apparent unlimited amount of business being offered for the future is responsible for the consideration of new industries. Cast iron pipe and sanitary pipe shops are well laden with business and quotatons of the products are being advanced. Cast iron pipe prices Monday advanced $3 per ton, the 4-inch pipe going to $69 and the 6-inch pipe to $66. Charcoal iron has advanced to $55 per ton and there is a splendid demand for the product.

RECENT WELDING AND CUTTING DEVELOPMENTS.

(Continued from Page 202)

inches in 12 minutes and a 21-inch shaft was cut completely off in about 15 minutes with this gas.

Tests have also been made which demonstrated that most successful and economical welds can be made on cast iron, aluminum, brass and copper and that it is a very efficient gas for lead burning.

Electric Cutting Department.

Various attempts have been made from time to time to develop apparatus which was commercially practical for cutting with the electric arc. The amperage required is so much greater than for welding that motor generator sets have been considered too expensive to install and too heavy to be made portable for electric arc cutting. Recently, however, an alternating current transformer type machine has been developed which weighs only about 400 pounds.

For cutting scrap at least 600 amperes are needed with carbon or graphite arc to make sufficient progress to realize on the investment. The ac machine offers for these 600 amperes a complete portable outfit, consisting of a transformer, which can be connected to the existing power lines in the shop or near the scrap pile, in general placing the machine near the scrap pile, running the primary leads to the nearest power supply and connecting one of the secondary leads to the scrap pile, the other to the carbon handle.

The machine, due to its efficiency and low demand, will operate, with the cost of power at 1c, at about 20c per hour. For this particular rough cutting this cost is very alluring as compared with gas, which runs from $2 to $3 per hour. For careful cutting, however, gas, due to its ability to cut without further need for machining, will be favored over electric cutting, and it is only on scrap cutting or such other rough work as cutting up cars or cutting rivet heads out of cars, or other steel to be scrapped, that the electric cutting with the graphite electrode is preferable. Where it is allowable, however, the cast is very much less.

One other development of electric cutting is an electrode which has a coating of chemicals which liberate oxygen at the temperature of the arc. During the war, this electrode was much used for nicking shell stock billets, and since then a field is being developed which possibly will outstrip the shell stock nicking in importance and quantity. This is the cleaning out of seams and incipient cracks in blooms, especially blooms of alloy steel. This same electrode uses the arc-liberated-oxygen to gouge out the cracks to a rounded bottom with flaring sides and this at a rate greatly in excess of the ordinary chipping process. For this use again the ac equipment from its characteristics and from its ease of connection to existing power supply comes to the front as the logical process for the work.

NOTES ON BOILER FEED WATER TREATMENT.

(Continued from page 211)

It is quite evident then, that to meet the new conditions that are obtaining in boiler plants today, some form of boiler feed water treatment must be used and if best results are to be obtained, that treatment must be flexible enough to meet the varying conditions of the raw water. A compound or method of treatment that is based on a single analysis will answer where the water is taken from deep wells or from some source where it has a constant proportion of impurities but if the water is taken from a stream which acts as a natural drainage canal, then the composition of the water will vary from day to day and the treatment should also vary. In any event, the treatment should take place and the incrusting solids removed by filtration or sedimentation before the water enters the harbor. As one engineer aptly puts it, "the only compound to put into a boiler is pure water."

FOREIGN RELATIONS

STATUS OF BELGIAN METALLURGICAL INDUSTRIES.

Trade Commissioner C. E. Herring, Brussels, Dec. 23, 1919.

The Belgian iron and steel industry is beginning to return to normal conditions although it will probably be the last of the important Belgian industries to regain pre-war production. Systematic sabotage by the occupying forces and removal of machinery and parts of mechanical apparatus was carried further in this industry than in any other. Thus at the time of the armistice, out of 54 blast furnaces in existence in Belgium in 1914, about 30 had been entirely destroyed or were so badly damaged as to necessitate extensive repairs. Of the 101 rolling mills operating in 1914 in the Province of Liege and Hainaut, 29 were completely ruined in the former and a large number in the latter.

It was in these two districts, which comprise the great majority of metallurgical plants, that systematic destruction was carried on most assiduously. Thus of the 23 blast furnaces in the Liege district in 1914, 10 were completely destroyed, and nine considerably damaged. The rolling mills of five large plants in the same district were entirely demolished; out of the 53 mills operating in 1914, 29 were entirely destroyed and three seriously damaged. It is expected that about 10 of the 53 mills in operation before the war will be actively producing by the beginning of 1920.

In the Province of Hainaut, 15 out of the 25 blast furnaces working before the war escaped destruction, but until recently only two of them were in active operation. The destruction of puddling furnaces was particularly serious in the Hainaut district, only 17 out of the 91 in operation before the war having been relighted a short time ago. Only six of the rolling mills in this Province had resumed production last Summer, as compared with 48 mills operating before the war. The scarcity and high prices of semi-manufactured products, as well as the fuel shortage, continue to retard production.

Cost of Replacing Destroyed Machinery—Shortage of Coke and Ore.

Methods of sabotage employed by the Germans were not always the same; in some plants the entire equipment and buildings were destroyed, while in others the machinery was removed, and the furnaces filled with concrete or rendered otherwise useless. In still other mills and blast furnaces essential parts of machinery were taken away, making the whole plant useless. One striking instance of sabotage may be cited. At the important Ougree-Marihaye steel works, which produced 50,000 tons monthly before the war about 44,000 metric tons of machinery and tools were scrapped and sent to Germany, about 4,000 tons of equipment and rolling stock were taken away intact, and 36,000 tons of raw materials were appropriated. The value of the destroyed machinery and materials was estimated at 45,000,000 francs, but replacement at present prices will greatly exceed this figure. The work of recovering stolen machinery taken into Germany has proceeded satisfactorily, but the restoration of the ruined and damaged furnaces and mills will eventually necessitate, of course, many new installations, which must be made at the present inflated prices.

The erection of new, thoroughly modern plants to replace some of the older mills and foundries which were destroyed will increase the future efficiency of the Belgian industry, however. For instance, the Providence works at Marchienne are constructing a steel plant to be completed by the end of 1920 which will reduce former labor requirements to a minimum.

The rapid revival of the Belgian iron and steel industry is, first of all, prevented by actual shortage of buildings and mechanical equipment. Scarcely less serious than this obstacle, however, is the acute shortage of coke and the continued difficulties of obtaining ore supplies. Belgium has always depended upon foreign countries for ore and for a large part of its coke-producing coal. In normal times this lack of raw materials for the metallurgical industries merely meant a comparatively slight increase in cost of production; at present it means an enforced reduction of the output which the furnaces and mills, only slightly damaged under the German occupation, might otherwise produce, and prevents the relighting of some furnaces. For instance, the relighting of the four furnaces of the important Societe de Sambre-et-Moselle, whose productive capacity is very large, is still delayed by failure to obtain sufficient supplies of coke and ore.

Steel Output Low Compared With Pre-War Production.

At present (December 15, 1919) the steel production of Belgium is estimated at 17 or 18 per cent of the pre-war output. If fuel and other raw materials were available in sufficient quantities, it is estimated that from 40 to 50 per cent of the pre-war production might even now be attained in the restored and undamaged plants. The situation has recently been complicated by a railway embargo on iron ore in Lorraine, and there have also been difficulties in obtaining customary supplies of ore from Luxemburg. Furthermore, the installments of industrial coal which Germany is obligated to provide under the Peace Treaty are said to arrive irregularly, and supplies of industrial coal are difficult to obtain from the Rhur district on account of transportation and other obstacles. The acute shortage of freight cars and other railway rolling stock on the Belgian railways is another contributing factor.

In spite of these difficulties, however, it is expected that the present production of about 17 per cent will shortly be augmented because of the lighting of new blast furnaces. The unemployment in the iron and steel industry has been greatly diminished during the last few months, it having been stated that on October 15 about 13,000 operatives were at work, as compared with about 24,000 employed in 1914. An indication of the present situation and prospects of the Belgian steel industry is furnished by the well-known Cockerill plant, the largest in Belgium which was greatly damaged during the war. The director of this plant was recently quoted as saying that for two, and perhaps three, years the large Belgian plants will find it difficult to produce more than 25 per cent of their normal output. Some plants which suffered less under the German occupation are, however, even now producing a considerably greater proportion of their pre-war output.

The cost of production in the iron and steel industry of Belgium has increased enormously. The high prices ruling for ores and fuel, together with the very high prices and exchange premium which must be paid for imports of semi-manufacturers necessary for reconstruction, seem to make a steadily rising market inevitable. Another factor is, of course, the increased costs of transportation and the delays and uncertainties in receiving materials. As in other Belgian industries, labor costs have advanced 100 per cent and more above pre-war levels.

In spite of the grave difficulties confronting the industry, there has been no weakness shown in the stocks of the various iron and steel plants. All of those now in operation are booked far ahead with orders, and it is said that former customers in export markets are generally seeking to renew their pre-war arrangements. At present, of course, the demand for iron and steel products is so great that price competition seems to be of minor importance.

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NEWS OF THE PLANTS

The Otis Steel Company, Cleveland, O., is planning for the construction of a new eight-inch mill in the vicinity of its present Riverside works. The plant will be equipped for the manufacture of all kinds of steel sheets, and details of the exact equipment installation are now being arranged. The company has been specializing in the production of sheared plates, light plates and steel sheets of various thickness, with plant consisting of a 72-inch plate mill and three other mills with two stands of cold rolls.

The Apollo Steel Company, Apollo, Pa., is planning for the erection of several large additions to its plant for increased capacity. The work will include two new jobbing mills, with capacity for rolling plates up to 54 inches wide; four hot sheet mills for the rolling of sheets up to 48 inches wide, and two stands of cold rolls. The company is planning to electrify its works throughout, and will install new electric apparatus, including an 1,800-hp motor for this purpose. The equipment at the new mills will be electrically operated. The other work at the plant will include the enlargement of the galvanizing department, and considerable new equipment will be installed in this branch of the works, including annealing and other apparatus. Three new 15-ton electric traveling cranes and two 30-ton electric cranes will also be installed. A new brick and steel warehouse, about 70x350 feet, will be constructed, and plans are also being considered for the installation of a plant for pulverizing coal. The company specializes in the production of galvanized sheets, with present plant capacity averaging about 5,000 tons of material a month. This output will be increased about 50 per cent through the new construction work. It is planned to inaugurate erection at an early date, and have the structures ready for service as soon as possible.

The National Rolling Mill Company, Vincennes, Ind., specializing in the production of billets, bars, etc., is planning for the construction of two new one-story reinforced-concrete additions to its plant for increased operations. The structures will be about 80x260 feet each in size.

The Algoma Steel Corporation, Saulte Ste. Marie, Ontario, Canada, has completed plans for the construction of a new structural steel mill at its plant, for the production of structural shapes of various kinds. The plant, with equipment, is estimated to cost in excess of $5,000,000. It is planned to inaugurate construction work with a gang of about 500 men at once, and to increase this complement to 1,000 men during the Summer. It is expected to have the plant ready for operation in about 12 months, giving employment to a total of about 600 men. The company is now operating four blast furnaces, and these units will be used to furnish steel for the new plant.

The Republic Iron & Steel Co., Youngstown, O., is planning for extensive additions to its steel mills at Niles, O., to provide for considerable increased output. It is planned to build eight new hot mills, to be used for the production of sheet steel, and six new cold mills, to be completely equipped for all features of production. The company recently arranged for a stock issue of $800,000, to be used for the proposed expansion.

The Weirton Steel Company, Weirton, W. Va., has acquired the coke plant of the Hillman Coal & Coke Co., known as plant No. 1 of the Thompson-Connellsville Coke Company in the Connellsville district, Pa. The plant comprises a total of 400 beehive ovens, with capacity of about 25,000 tons of coke per month. In connection with this acquirement the company has also secured about 1,000 acres of coal lands in the same section, and plans for extensive development work.

Winfield S. Barnes & Co., Twentieth street and Erie avenue, Philadelphia, Pa., manufacturers of structural steel shapes, are having plans prepared for the construction of a four-story brick addition to their plant for increased capacity. The structure will be about 100x300 feet, and is estimated to cost approximately $200,000. Winfield S. Barnes heads the company.

The Van Dorn Iron Works, East Seventy-ninth street, Cleveland, O., has plans under way for the construction of two plant additions for considerable increased output. The structures are estimated to cost about $50,000.

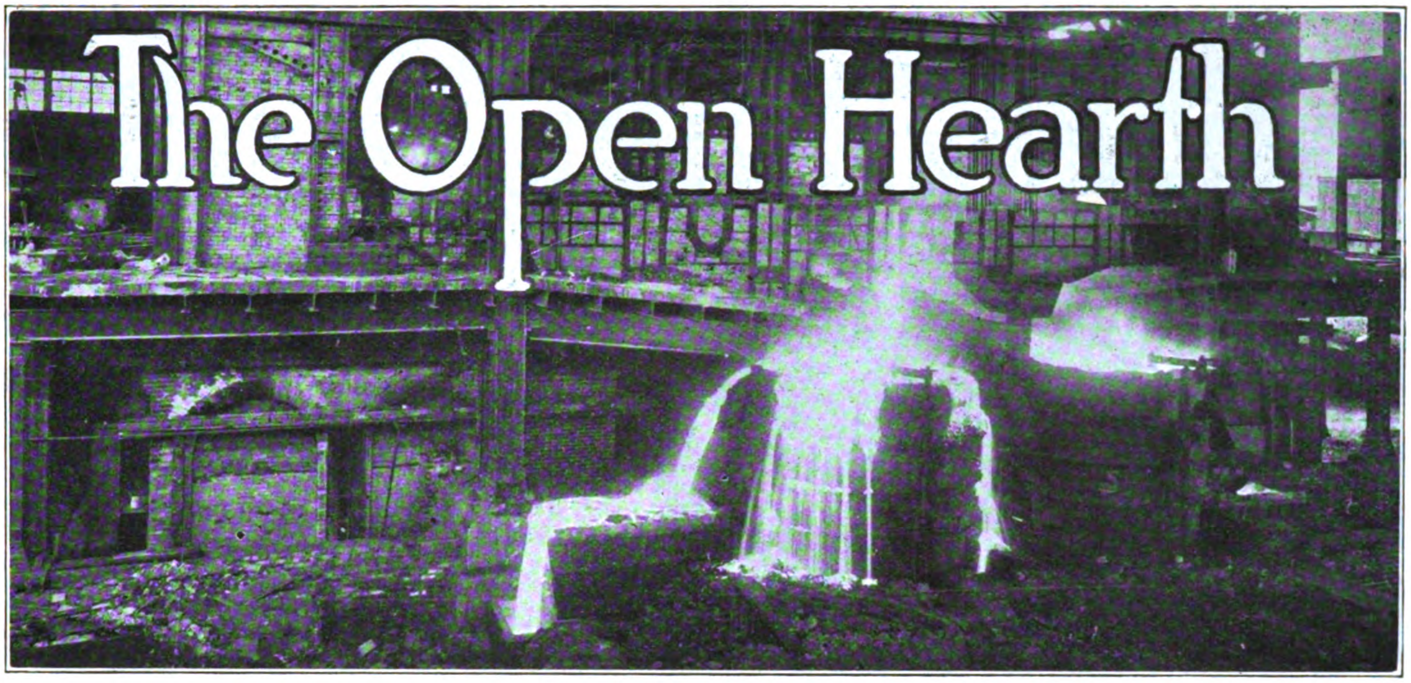
The Judson Manufacturing Company, San Francisco, Cal., has completed the construction of a new 30-ton open-hearth furnace, making a total of three such units at the plant. Extensive improvement work has also been under way, and the capacity of the rolling mill increased. It is said that this is the only plant on the Pacific coast which manufactures sand cast forging ingots. The company now has an open-hearth steel capacity of about 6,000 tons of material a month.

The Frasse Steel Company, Hartford, Conn., recently incorporated with a capital of $1,000,000 to take over the business of the Peter A. Frasse Company, is planning for the construction of additions to its works for considerable increased capacity. A new shop building will be erected, about 25x320 feet in size, as well as a number of other structures. It is planned to bring the capacity up to about 40,000 tons of material a year; the present output is about 25,000 tons. A. E. Brion is president and Lester Brion is treasurer.

Baldwin's Canadian Steel Corporation, Toronto, Canada, is planning for the erection of several additions to its plant to cost about $1,000,000. Three new tinplate mills will be constructed, and present buildings remodeled and equipped. The company is now operating ten electric steel furnaces and through the war period the plant was used for the manufacture of munitions. This works was formerly the property of the British Forgings Company.

Extensive construction work is under way on a number of new steel plants in Ohio for the manufacture of steel sheets and kindred specialties. The Superior Sheet Steel Company, Canton, is now building a plant comprising eight sheet mills, with cold rolling, annealing and galvanizing departments. The plant will have a capacity of about 60,000 tons of sheet steel per year. Extensive property adjoining the works has been acquired for proposed later additions. The Newton Steel Company, Newton Falls, organized in 1919, has under construction a large plant for the manufacture of sheets to be used for automobile manufacture. This plant will consist of eight finishing mills, and will be equipped for annual capacity of about 48,000 tons of finished material. It is planned to have the plant ready for service early in March. The Mansfield Sheet & Tin Plate Co., Mansfield, has construction work well under way on four new sheet mills. The new extension will be ready for operation in March, and will give the company an annual output of about 80,000 tons of finished sheet steel. The American Rolling Mill Company, Middletown, has commenced the construction of 12 new sheet mills at its plant. It is planned to have the buildings ready for operation early in July. The Crucible Steel Forge Company, Cleveland, is planning for the early construction of an addition to its plant, about 60x900 feet, to be equipped with heavy type mills and reheating furnaces. The company specializes in the manufacture of steel and bars.

The Open Hearth



William H. Keen is now manager of tool steel production for the Hess Steel Corporation, Baltimore, Md. Mr. Keen has had extensive experience in the metallurgical industries having been previously connected with the United States Copper Products Company and with the Firth Sterling Steel Company. The complete line of tool steels which the Hess corporation is now manufacturing will be in direct charge of Mr. Keen.

V V

John D. Crawford, formerly connected with the Maryland Pressed Steel Company, Hagerstown, Md., as consulting engineer and in charge of research and development has taken a position with the Wellman-Seaver-Morgan Company, in an engineering capacity.

V V

J. G. Coles, who was formerly with the Standard Forgings Company, has recently been appointed manager of sales for the Kropp Forge Company, Chicago.

V V

E. F. Jones, formerly vice president of the Elyria Iron & Steel Co., Elyria, O., has been elected president of the Republic Rubber Corporation and the Republic Rubber Company, Youngstown, O.

V V

C. W. Owen has resigned as secretary and treasurer of the Old Dominion Iron & Coke Corporation, Roanoke, Va. Mr. Owen will be succeeded by O. Byrd Newton.

V V

E. France is now connected with the Erie Forge Company in the capacity of consulting engineer. Mr. France was formerly steel foundry superintendent for the Otis Steel Company, Cleveland, O.

V V

J. D. Jones was appointed general manager of the Algoma Steel Corporation, Ltd., Sault Ste. Marie, Ontario, effective February 21.

V V

J. E. Fitzgerald, assistant general manager of sales of the Brier Hill Steel Company, Youngstown, O., and A. E. Quere, also of the sales department of the Brier Hill Steel Company, have resigned, effective March 1, to engage in the sale of iron and steel products with headquarters at Niles, O.

V V

L. F. Quigg succeeds H. H. Townsend as open hearth superintendent at the Franklin Works of the Cambria Steel Company, Johnstown, Pa. Mr. Quigg has been connected with the Cambria Steel Company for a number of years. Mr. Townsend is taking a position with the Haws Refractories Company at Johnstown.

Edward A. Lembeck, formerly connected with the sales offices of the Republic Iron & Steel Co., Youngstown, O., is now connected with the sales office of the same concern in the Oliver Building, Pittsburgh.

V V

W. H. Morris is now general superintendent of the Peerless Coal Company, and the Mineral State Coal Company, located at Buckhannon and Moundsville, W. Va. Mr. Morris was formerly superintendent of the mining department of the Cambria Steel Company, Johnstown, Pa.

V V

W. W. Frazier has been appointed assistant superintendent of the Reading Iron Company's tube works at Reading, Pa. Mr. Frazier has had very extensive experience in the steel industry, having been previously connected with the Lorain plant of the National Tube Co., La Belle Iron Works, the Youngstown Sheet & Tube Co., A. M. Byers Company, the United States Steel Corporation at Neville Island and the Sparrows Point plant of the Bethlehem Steel Company.

V V

Paul W. Shale has been appointed secretary to James H. Grose, president of the Brier Hill Steel Company.

V V

Ed. E. Hughes, formerly general manager of the Franklin Steel Works, Franklin, Pa., is now engaged in another line of business in New York. Mr. Hughes maintains his connection with the Franklin Steel Works in an advisory capacity and with the title of vice president. C. F. Mackey, formerly assistant general manager succeeded Mr. Hughes.

V V

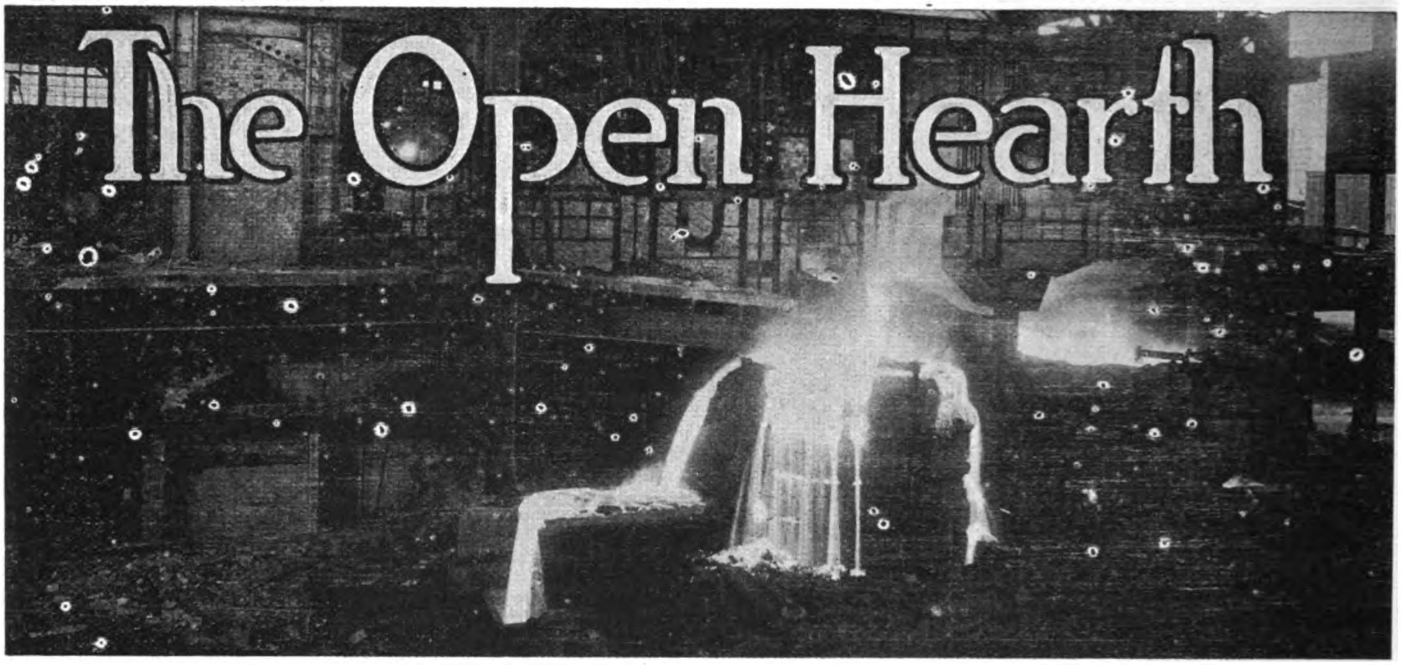
P. D. Mackey is now general superintendent of the Eastern Steel Company, Pottsville, Pa. Mr. Mackey has recently resigned his position with Henry Disston & Sons, Tacony, Philadelphia. Mr. Mackey has been connected with the steel industry for a number of years, having been previously connected with the Carnegie Steel Company, Republic Iron & Steel Co., Colorado Fuel & Iron Co., and the Bethlehem Steel Company.

V V

Willard S. Haring is now assistant general manager of sales for the Alan Wood Iron & Steel Co., Philadelphia.

V V

Walter B. Eichleay, of the John Eichleay, Jr. Company, Pittsburgh, has been elected president of the Monongahela Iron & Steel Co., Pittsburgh. Mr. Robert Lock, who was formerly president of this concern, has resigned from that position and is now interested in a new company, which is to erect a sheet mill at Ashtabula, O.



The Open Hearth

Luther A. Davis, formerly production superintendent of the Standard Screw Company, Corry, Pa., is now connected with the Hydraulic Pressed Steel Company, Cleveland.

V V

W. P. Starkey has resigned as vice president and general superintendent of the Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa. Mr. Starkey will be actively engaged in supervising the interests of the Starkey Produce Company.

V V

W. H. Lemont, with headquarters at Benwood, W. Va., is safety director of the plants of the Wheeling Steel & Iron Co.

V V

Gilbert F. Close, who has for the past year and a half served as a confidential employe at the White House, has accepted a position as assistant to the president of the Commonwealth Steel Company, St. Louis, Mo.

V V

Roy E. Brakeman is now general manager of the Otis Steel Company, Cleveland, O. Mr. Brakeman served in a similar capacity at the Fairfield, Ala., plant of the American Steel & Wire Co.

V V

Lewis H. Miller, formerly connected with the Babcock & Wilcox Co., Baberton, O., has become mechanical engineer of the Cromwell Steel Company, Lorain, O.

V V

Dr. Arthur B. Hitch, formerly chief chemist for the Ashland Iron & Mining Co., Ashland, Ky., has accepted a position of research chemist with the E. I. du Pont de Nemours & Co., Inc., at Wilmington, Del.

V V

W. H. Ramage has been promoted from assistant chief engineer to chief engineer of the Brier Hill Steel Company, Youngstown, O., succeeding Harry Z. Bixler, who has recently resigned. Mr. Bixler has been chief engineer of this company ever since its incorporation, and was formerly chief engineer of the Youngstown Steel Company predecessor of the Brier Hill Steel Company.

V V

Gustav A. Merkt has been appointed chief engineer for the Clinton-Wright Wire Company, Worcester, Mass. Mr. Merkt was previously connected in a similar capacity with the American Tube & Stamping Co.

V V

G. D. Cameron has been elected to the board of directors of the Youngstown Sheet & Tube Co., succeeding Amasa Stone Mather, deceased. A. E. Adams succeeds Hugh B. Wick.

F. L. Collins has become affiliated with Freyn, Brassert & Co., 645 Peoples Gas Building, Chicago, as power and electrical engineer. Mr. Collins, formerly was connected with the Illinois Steel Co., at South and Gary works and with the Universal Portland Cement Company, at Buffington, as electrical engineer. He later joined the Dominion Iron & Steel Co., Ltd., Sydney, N. S., as chief electrical engineer. Subsequently was connected with the ordnance department of the United States Steel Corporation, at Neville Island, near Pittsburgh and lately was chief electrical engineer of the Pittsburgh Crucible Steel Co., Pittsburgh.

V V

Thomas J. Fitzgerald, formerly chief engineer of the Midvale Steel & Ordnance Co. at the Eddystone Rifle Plant, Eddystone, Pa., is now vice president and works engineer of the Sturdi-Truck Manufacturing Co., Holyoke, Mass.

V V

The Phoenix Iron Works Co., Meadville, Pa., announces the appointment of K. B. Thorndike as sales engineer, in charge of its New York office, Fifth Avenue Building; also the opening of its Boston office in the Old South Building, with Paul C. Rodgers, district sales manager, in charge.

V V

George Satterthwaite, vice president and treasurer of the Tacony Steel Company, Tacony, Pa., since March, 1919, has been elected vice president of the Penn-Seaboard Steel Corporation.

V V

Charles O. Gustavsen is now superintendent of the bar mill of the Canton Sheet Steel Co. Mr. Gustavsen was formerly foreman of the roll shop of the Lowellville works of the Sharon Steel Hoop Co., he also was connected with the Colorado Fuel & Iron Co., Pueblo, Colo.

V V

John B. Warren has been elected president of the Penn Seaboard Steel Corporation, New York. Mr. Warren was formerly president and general manager of the Tacony Steel Company, which has recently been acquired by the Penn Seaboard Steel Corporation.

V V

S. H. Yahres, for a number of years connected with MacIntosh, Hemphill & Co., and for the last eight years secretary in that concern, has resigned.

V V

David E. Tracy, formerly general superintendent and for the past five years president of the Harrisburg Pipe & Pipe Bending Co., Harrisburg, Pa., resigned as president at the recent meeting of the board of directors.

INDUSTRIAL RELATIONS

SAFETY PRACTICE IN THE STEEL INDUSTRY.

The National Safety Council has recently issued a bulletin No. Me 2 on "Safe Practices" which has particular reference to the steel industry. The pamphlet is intended to cover the fundamental safety requirements of blast furnaces, cast houses, stoves, gas cleaning apparatus, skip hoists, pig casting machines, stock houses, and stock handling machinery. While general in their application, many of them unquestionably will have to be adapted to local conditions and construction. The following excerpts are taken from this bulletin.

Furnace Stack.

A telephone or speaking tube should be provided at each blast furnace, between the skip hoist operators' house and the stove tenders shanty. This installation should include a connection to the furnace top for use of signal men or men engaged in consructing, repairing, or inspecting the top of furnace. A gong, whistle, or other alarm located at the above mentioned points should supplement this equipment. It is also advisable to have some means of quick communication between the cast house or blower's office and the skip-hoist operator's house.

Standard platforms, with railings and toe boards, should be installed at all elevated points where employes must go daily, or frequently, to perform their duties. Such platforms should be provided for the outriggers on top of the furnace, at steam or air cylinders, for the bells, and at the explosion valves. Permanent stairways or ladders of substantial fireproof construction should be provided as means of access to all platforms.

Some of the larger companies have found where it is possible for one elevator to serve a group of furnaces, that this arrangement is desirable from an operating standpoint. Such an elevator may be used for handling small material, also for hoisting men, thus assuring closer supervision of the top mechanism. Where the installation cost of a small passenger elevator would not be excessive, and a group of furnaces could advantageously be served by one, such an installation would seem advisable. The elevator is usually installed to connect with the upper stove platform.

A steam connection (not less than 2-inch) taken from a 6-inch steam line is recommended for both the dust catchers and the cold blast mains. Two steam connections are recommended for the cold blast pipes—one near the snort valve at the stoves and the other one near the engines. It is recommended also that there be two valves in the steam connection to the cold-blast pipes, one closing it against air pressure and the other against steam pressure. A drip cock between these valves should be left open to detect leaks and prevent leakage of steam into the blast.

Gas Cleaning Systems.

Every reasonable precaution should be taken to obviate the necessity for men working in gaseous areas. All cleaning and repairing of washers or driers while the furnace is in operation should be done only after water valves and goggle valves have been closed. Particular attention should be given to the design of the bottom of the washer where the waste water is discharged Clogging may be prevented by discharging the bulk of the water through a syphon pipe forming a gas seal and providing a separate drain (quick acting valve) at the lowest point of the seal, or by some equally efficient means, which will prevent an accumulation at the point where the sediment usually collects.

The water seal should be placed as near the furnace as possible, not more than one dust catcher intervening between the water seal and the furnace.

Care is necessary in designing the gas inlet connection so as to minimize the possibility of accumulations of flue dust forming at this point, also to provide facilities for safely and easily removing such accumulations.

One or more valves by which the gas can be shut off from each side should be provided at all gas cleaning and washing plants, in addition to the water seal ahead of the washer. A plate (goggle) valve is recommended.

In addition to the gas valves mentioned above, provisions should be made so that any furnace may be completely cut off from the main gas leads. It is advisable that a sufficient number of flush valves be provided so that mains may be readily washed out from the outside during operations.

A sufficient number of manholes should be provided in all gas mains for ventilation and ready access. It is recommended that manholes be at least 21 inches in diameter.

Breathing apparatus should be provided for use of workmen who must enter gaseous areas.

Cast Houses.

Casting holes where ladles are loaded under the floor should preferably be grated. Where gratings are not practicable railings should be provided.

Cast house floors should be amply provided with exits, to prevent men being trapped in event of a breakout. These should be sufficient in width to permit quick escape.

A hinged or removable shield, or other efficient means, should be provided for the protection of workmen at cinder and iron notches.

Pig Machines.

Shield or shelter houses should be provided for the protection of the pourers. Pig machine chains should be sheeted underneath at passageways, and where men are stationed. A shield should be provided at the discharge end of conveyor to protect end men from flying spalls. A brick wall or steel plate partition should be provided to protect ladle cleaners. Some companies have adopted the practice of keeping kish pits drained and spraying water on the hot kish. Valves, switches, and operating levers that control the movement of machinery covered by these suggestions should be provided with locking devices.

Blowing Out Blast Furnaces.

When gas is no longer suitable for use in stoves or boilers, and water seals are to be filled, steam should be immediately turned into dust catchers between water seal and furnaces. All bleeders on dust catchers should be kept closed, thus driving the gas out through the top of the furnace where the bleeders are open. Water sprays should be put in dry holes and on big bell. The big bell should be kept partially open, held tight against chains, rods or lugs inserted between bell and hopper.

While blowing out a blast furnace the bell and hopper should never be kept cool by closing the bells tightly and filling the hopper with water. Very disastrous results have occurred where this dangerous practice was followed.

When, during the blowing-out period the blast has been taken off at casting time, or otherwise, the water should be shut off on top until blast is again put on.

When a furnace is blown out and after the blast is taken off the tuyeres should be plugged with clay and the blow pipes should be taken down one at a time, following in turn around the furnace so that in case any of the scaffolding should fall, the danger to the crew is minimized. The furnace floor should be roped off and no one permitted to go near the furnace except under personal instruction of the foreman. Steam should be kept going into the dust catcher system for at least 24 hours after the blast is taken off the furnace.

The blowing engine should not be completely stopped but should be kept slowly running until all blow pipes are down and the tuyeres are plugged with clay. After the tuyeres are plugged, and the blast is completely off, water should be kept going into the top of the furnace until the fire has been drowned out. The wet stock should then be removed from the furnace through the tuyeres and cinder notches.

Some Pointers on By-Product Coke Oven Operations

LOW-TEMPERATURE CARBONIZATION OF COAL

By S. W. Parr and T. E. Laying.

The low-temperature carbonization of coal involves the carrying out of the coking process under conditions wherein neither the coal mass nor any of the passageways through which the volatile products pass are heated above 700 or 800 degrees C. For convenience in this discussion, the single number 750 degrees will be used to designate the maximum range. This temperature is not selected arbitrarily; it is the result of certain natural conditions that are inherent in the substances involved. Two of these conditions are sufficiently pronounced to suggest a line of demarcation at this point as follows: (1) Below 750 degrees, all the heavy hydrocarbons are expelled, which means that, at these lower temperatures, the illuminants, the gases of high calorific value, and the condensible oils are discharged; above 750 degrees, there are given off the lean, non-illuminating gases consisting for the most part of hydrogen and marsh gas and having no condensible constituents present. (2) Below 750 degrees, there is substantialy no secondary decomposition; above 750 degrees, the volatile products are readily decomposed, forming tars, napththalene, free carbon, etc.

It is not intended to maintain that no secondary decompositions occur below 750 degrees. Many recent studies have demonstrated the practicability, especially in the presence of catalytic substances, of cracking certain of the hydrocarbon compounds; but at these low temperatures the step is a moderate one, as, for example, from xylene to toluene or from toulene to an anthracene. These changes are moderate in amount. Not only do the reactions proceed slowly but they are subjected to the decomposing conditions for only a short time. This is evident when it is recalled that at these initial temperatures the decomposition of the coal is very rapid and, if anywhere near a neutral pressure is maintained, the movement of the evolved gases is lively and reduces, correspondingly, the time for the retention of the gases in the passageways where these milder decomposing conditions exist.

It is acknowledged that the maintenance of the temperature conditions at the present time has only an ideal and not a practical status. Actual operations under these conditions, as an industrial accomplishment, is still in the experimental stage. However, many tendencies and many experimenters, not to say promoters, are working toward this goal and the topic is certain to be one of great interest until we have come much nearer the ideal in practice. It is not the purpose of this paper to discuss possible methods whereby this end may be attained. Any industrial process, has in the main only negative results to report when it is in the development stage; otherwise it would not be in that stage. There is a definite value, however, in setting forth in quantitative terms, so far as they may have been determined, the factors that represent the normal yield to be expected if conditions are maintained as planned. An added reason for offering such data is the tendency to make extravagant and unwarranted statements regarding the value and quantities that accompany the low-temperature process.

The apparatus employed in these experiments is capable of handling 25 to 35 pounds of coal at a charge. The heat is applied by means of an electric current, the amount of resistance wire being so adjusted as to produce a temperature not over 800 degrees C. The cross-section of the retort is 7¼ inches. Pyrometer readings are taken at the center of the mass and next to the wall of the retort. The coals employed were mainly from Illinois but the experiments were extended to include samples from Indiana, Kentucky, West Virginia, and Pennsylvania. As already noted, it is the purpose of this paper to give as nearly as possible what may be looked upon as a normal value for the different products obtainable from the various coal samples employed. In this particular, therefore, it is supplementary to bulletins already published by the Engineering Experiment Station of the University of Illinois, wherein chief attention was given to methods of manipulation and where quantitive data as to by-products were meager and occasionaly in error.[*]

The results given in the tables are sufficiently specific and a further discussion must be reserved for the bulletin wherein it is hoped that additional data will be available concerning the composition of certain of the by-products, especially the tars.

Paper read before February meeting of A. I. M. & M. E.

[*] S. W. Parr and H. L. Olin: The Cooking of Coal at Low Temperature, Bulletin 60 and Bulletin 79 (1913, 1915).

Table 1—Coke from Low-Temperature Carbonization.

No.	Sample.	Moisture, Per Cent.	Ash, Per Cent.	Volatile Matter, Per Cent.	Fixed Carbon, Per Cent.	Sulphur, Per Cent.	Btu.
125	Herron, Williamson Co., Illinois	0.11	13.48	6.01	80.40	1.89	12.627
128	Harrisburg Saline Co., Illinois	0.55	10.65	6.15	82.65	1.78	13.154
129	Harrisburg Saline Co., Illinois	0.25	9.50	11.70	78.55	1.94	13,267
140	Georgetown, Vermilion Co., Illinois	0.22	15.59	5.02	79.17	1.47	
130	Fairmont, W. Va., Pittsburgh seam, high volatile	0.63	11.11	11.64	76.62	1.17	13,624
131	Fairmont, W. Va., Pittsburgh seam, high volatile	0.61	10.31	5.52	83.36	1.00	13916
132	Fairmont, W. Va., Pittsburgh seam, high volatile	0.31	10.03	4.12	85.78	0.90	13.851
135	"Jenner Coal," Somerset Co., Pa., C prime seam, low volatile	0.29	6.75	3.83	87.69	0.77	14.430
136	"Jenner Coal," Somerset Co., Pa., C prime seam, low volatile	0.18	8.00	4.15	87.67	0.75	14,281

Table 2—Gas from Low-Temperature Carbonization.

No.	Coal Sample.	Yield, in Cubic Foot per Pound of Coal.	Heat Value in Each Foot, Btu.			Sulphur in Each Foot-grain per 100 Ft.		
			A	B	C	A	B	C
125	Herron, Williamson Co., Illinois	3.0	967	685	435	244	44	12
128	Harrisburg Saline Co., Illinois	3.2	900	628	428	391	200	96
129	Harrisburg Saline Co., Illinois	3.2	892	676	443	303	206	93
140	Georgetown, Vermilion Co., Illinois	3.4	845	541	465	198	122	28
130	Fairmont, W. Va., Pittsburgh seam, high volatile	3.4	995	685	462	404	254	34
131	Fairmont, W. Va., Pittsburgh seam, high volatile	3.3	950	631	430	444	235	34
132	Fairmont, W. Va., Pittsburgh seam, high volatile	3.3	946	678	450	318	59	52
135	"Jenner Coal" Somerset Co., Pa., C prime seam, low volatile	3.2	632	421	362	11	2	0
136	"Jenner Coal" Somerset Co., Pa., C prime seam, low volatile	3.7	745	564	410	19	13	0

WITH THE EQUIPMENT MANUFACTURERS

TWO NEW SAFETY STARTERS HAVE NO EXPOSED LIVE PARTS.

It is generally conceded that unprotected power terminals are as much a source of danger as unguarded gears and machines, hence as a safety measure electrical societies are encouraging the complete enclosing of motor starters to protect workmen from coming in contact with live parts. Although safety conditions are primarily the cause of the demand for enclosed starters, some installations require the enclosed type as a means of keeping the contact making parts clean and the starter in good operating condition.

The latest additions to the line of enclosed starters manufactured by the Cutler-Hammer Manufacturing Company, of Milwaukee and New York, are known as Bulletins 2111 and 6193. The former consists of the familiar type of direct current face plate starter enclosed in a sheet metal case having an external lever which engages the movable arm of the starter, Fig. 1. The external, or operating lever is insulated from the revolving contact arm by a block of molded insulation. A pointer on the lever and legends stamped on the cover indicate to the workman whether the starter is "off" or "on." In the smallest size of starter a knob of black insulating composition is provided in place of the operating lever. A low-voltage release coil in series with the shunt field protects the motor in case of voltage failure or if the field should be opened while the motor is running. The armature resistor is completely enclosed in the starter case, which is kept well ventilated by a flue in the top.

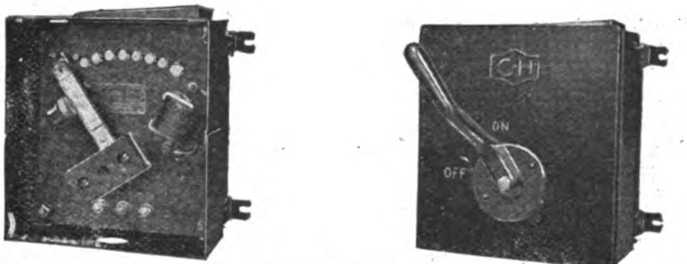


Fig. 1—Direct current face plate starter enclosed in a sheet metal case having an external lever which engages the movable arm of the starter.

With the exception of the enclosed feature the Bulletin 2111 starter is similar to the latest design open face type of C-H standard starter, which can be changed to the enclosed starter described above in the few minutes required to change the operating lever and put on the enclosing case. Both the enclosed and open type starters are used with dc motors up to 50 hp, operating at 115, 230 and 500 volts.

Bulletin 6193 is an automatic motor starter panel of the counter E. M. F. type completely enclosed in a cast iron case with a hinged cover. The automatic feature is obtained by an accelerating contactor which closes when the motor attains about three-fourths full speed, and automatically shunts out the starting resistor. A magnetic main line contactor mounted on the panel allows remote control from two push button switches of the momentary contact type. The operation of the contactors in conjunction with the push button switches is as follows: Pressing the "run" button closes the magnetic main line switch, thereby starting the motor with the armature resistor in circuit. The motor accelerates until it reaches about three-fourths normal speed, when the resistor is automatically cut out of circuit by the closing of the accelerating contactor, the operating coil of which is connected across the motor leads and is energized by the counter E. M. F. of the armature. The motor is stopped by pressing the "stop" button, or by voltage failure, both of which cause the main line contactor to drop out. A common snap switch, a float switch or a pressure regulator can also be used for the remote control of the motor. When remote control is not desired the magnetic main line contactor is omitted, and the motor is started by a fused knife switch mounted on the panel with an operating handle outside of the case. The handle can be locked in the open position to prevent unauthorized operation. Interlocks prevent lifting the cover while the switch is closed or throwing the switch with the cover opened. When the knife switch is used, low voltage release is inherent in the accelerating contactor, which will again close after the voltage returns and the motor has accelerated to three-fourths normal speed, provided the knife switch is still in the closed position. The cast iron enclosing case is arranged for conduit wiring and can be mounted on a wall or any flat surface. This starter is for use with small dc motors not rated over 2 hp at 115 volts or 3 hp at 230 volts.

With many factories and shops today equipped throughout with individual motor drives, the field of application of these starters is very broad. They give particularly satisfactory service with motors starting with normal load and operating with unvarying voltage, such as those driving fans, blowers, pumps lathes, drills and small motor-generator sets for arc welding By employing a separate field rheostat the Bulletin 6193 starter may be used for the control of motors operating at variable speeds above normal.

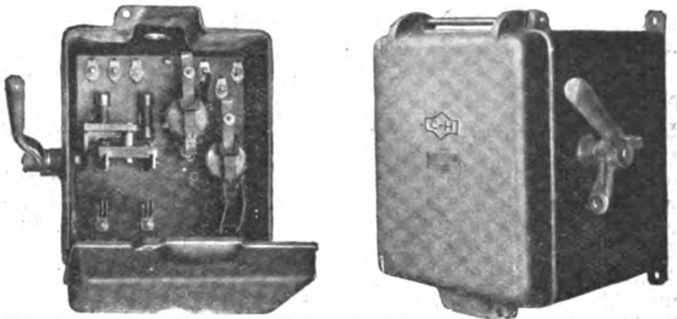


Fig. 2—Automatic meter starter panel of the counter E. M. F. type completely enclosed in a cast iron case with hinged cover.

OUTDOOR SERVICE FOOT WARMER.

An electric foot warmer made by the Westinghouse Electric and Manufacturing Company, and designed for outdoor service, makes it possible, in Winter weather, greatly to relieve outdoor workers, obliged to remain in one spot for long periods of time, from the discomfort of cold feet. Investigation as to how this relief could be furnished by means of an electric heater, resulted in the development of an electric foot warmer different from anything previously on the market.

The warmer is manufactured in two sizes, one of which, measuring 14 inches wide 20 inches long and 3½ inches high, is made either of cast iron or brass. This style is provided with a three-heat snap switch by which three-heat operation can be obtained. The amount of power consumed can be regulated to 200, 100 and 50 watts, respectively, at 120 volts, for the different positions of the switch. This size can also be operated on 240-volt service and rated at 200 watts single heat. The smaller type, 12 inches wide, 16 inches long and 3½ inches high, is rated at 200-watts on 120 volts single heat. Six feet of cord with a snap switch is supplied with each warmer. The rubber insulated cable enters the device through a bell-mouthed waterproof fitting mounted in the middle of one end.

TRADE PUBLICATIONS

The Hauck Manufacturing Co., Brooklyn, N. Y., has issued a new bulletin, No. 119, which illustrates and describes in detail the many different types of oil burners, manufactured by this firm. The book has also a number of pictures showing the practical application of the Hauck burners to various types of furnaces. A part of the booklet is devoted to sketches showing other ways and means of using Hauck burners. Throughout the entire book are given results of tests.

The Blaw-Knox Co., Pittsburgh, Pa., has recently put out a small folder describing the extent to which Blaw steel forms can be used in conection with concrete construction projects.

TRADE NOTES

The Hauck Burner Service Station at Pittsburgh has moved its office from 2930 Penn avenue to 105 Wood street, where they have a large display window and are more able to give better service in every way. The Hauck Burner Service Station at Boston has moved from 70 High street to larger quarters at 149 Berkeley street, corner Columbus avenue. This new office consists of a large display window, store, office and space for demonstration. The Hauck Burner Service Station at Cleveland has moved from 2114 Superior Viaduct. It is now located at 1106 Walnut avenue, where the representative is in better position to give excellent service, make demonstrations, etc.

The Easton Car & Construction Co., in order to give their customers in the Detroit district the service that their business demands have opened a branch office in Room 400, Penobscot Building, Detroit, Mich., in charge of Mr. H. H. Siff, the district sales engineer, who is experienced in industrial railway matters, and whose services are at the command of those interested. The Easton company announces that their branch offices will carry a stock of spare parts as soon as the demand for such service makes it advisable.

Several additions and changes in the sales and advertising departments of the Square D Company of Detroit, Mich., became effective February 1. E. A. Printz, formerly district sales manager of the Chicago territory, was made sales manager, A. MacLachlan continuing in the capacity of secretary and director of distribution. D. M. Stone, formerly district sales manager of the Pittsburgh territory, was made district sales manager of the Detroit territory. J. A. Jaques, formerly in charge of the New York territory as district sales manager, was given the district sales managership of the Pittsburgh territory, and H. W. Spahn, district sales manager of the Buffalo territory, was placed in charge of New York. D. H. Colcord, formerly of the department of publicity of the Westinghouse Air Brake Company of Pittsburgh was appointed director of research engineering. The annual sales conference of the Square D Company was held at the Hotel Statler, Detroit, February 16, 17 and 18.

Arthur G. McKee & Co., 2422 Euclid avenue, Cleveland, O., has been awarded a contract for furnishing a 5-unit Kling-Weidlein dry gas cleaner for the blast furnace plant of The Appleby Iron Co., Ltd., Scunthorpe, Lincolnshire, England. The decision of the Appleby Iron Co., to install this equipment was reached after a thorough investigation by their representatives of gas cleaning equipment in the United States and England. This is the second Kling-Weidlein dry gas cleaner installation being provided by Arthur G. McKee & Co. for erection in England, and makes a total of 11 installations at present in operation or under construction.

The Keystone Lubricating Company held its annual convention January 14 to 17 and was attended by the district sales managers, district office managers and salesmen. The convention was opened with a talk by Mr. H. A. Buzby, vice president, on "The History of the Company." This was followed by a talk on "Credit Relations," by Mr. W. F. Buzby, the treasurer. Then came a series of open discussions on service, sales and consumers' technical problems by the following members of the organization: Mr. Lowry, Mr. Kline, Mr. Cassady, Mr. Bennett, Mr. Webster, Mr. Binns, Mr. Yerkes, Mr. Kimbro, Mr. Hall, Mr. Moyer, Mr. Dickinson, Mr. K. K. Buzby, Mr. Lawrence, Mr. Paterson and Mr. Jackson. One of the most timely addresses was that delivered by Mr. N. T. Buzby, secretary of the company, who chose for his topic, "Our Foreign Relations." Mr. Buzby has but recently returned from abroad where he had ample opportunity to closely study the trend of foreign markets, the opportunities and the problems. Mr. D. S. Paterson, marine engineer, related interesting experiences in the launching of government ships in his talk on "Results and Rewards." "Lubricants and Their Application" was the subject of an illustrated talk by Mr. T. O. Organ, consulting engineer. The concluding address was made by Mr. A. C. Buzby, president and founder of the company, who was presented with a beautiful testimonial from the members of the organization. Mr. Hall, the chairman, was congratulated upon the success of the convention and those who attended are enthusiastically looking forward to 1921.

In order to care for expanding business on Yarway products, and give customers in the state of Michigan the best possible service, the Yarnall-Waring Company has opened a branch office in the Builders' and Traders' Exchange, Penobscot Building, Detroit, in charge of Mr. Walter G. Heacock, branch manager.

The Pittsburgh Chapter of the American Association of Engineers recently held its annual election of officers and elected the following: C. L. Kirk, president; I. Charles Palmer, first vice president; C. M. Herrick, second vice president; L. C. Rowell, third vice president; G. W. Johnston, recording secretary; M. F. Snell, treasurer. The following engineers were elected to the executive committee: S. D. Foster, S. H. Brenaman, M. Z. Balph, F. D. Manning, F. E. N. Thatcher, E. O. Garrett, W. R. Smith, S. A. Shubin. B. A. Ludgate, as the past president, becomes a member of the committee.

The Electric Furnace Company, Alliance, O., added the following number of installations during the last quarter of 1919, which are of special interest on account of the new type of equipment involved, and the special alloys which are to be melted in these furnaces.

The Standard Sanitary Manufacturing Company, Louisville, Ky., has just installed its fifth Baily Electric Furnace for melting yellow brass.

McRae Roberts Company, Detroit, Mich., has installed its third Baily furnace.

Nolte Brass Company, Springfield, O., has recently installed its second Baily furnace.

White & Brothers, Philadelphia, Pa., has installed a 105-kw furnace, 1,500 capacity.

Akron Bronze & Aluminum Co., Akron, O., has installed a 105-kw furnace, melting red and yellow brass.

Union Brass & Metals Co., St. Paul, Minn., has installed a 105-kw furnace for melting red and yellow brass.

American Hardware Company, New Britain, Conn., has installed a 105-kw furnace for melting brass.

Roberts Brass Works, Detroit, Mich., has placed an order for three Baily furnaces, each of 1,500 pounds capacity.

Westinghouse Electric & Manufacturing Co., Pittsburgh, Pa., has installed a 50-kw furnace of 500 pounds hearth capacity.

Wasson Piston Ring Co., Plainfield, N. J., has placed an order for a 500-pound furnace for melting grey iron.

Kayline Company, Cleveland, O., has purchased a 50-kw furnace with 500 pounds hearth capacity, for melting yellow brass.

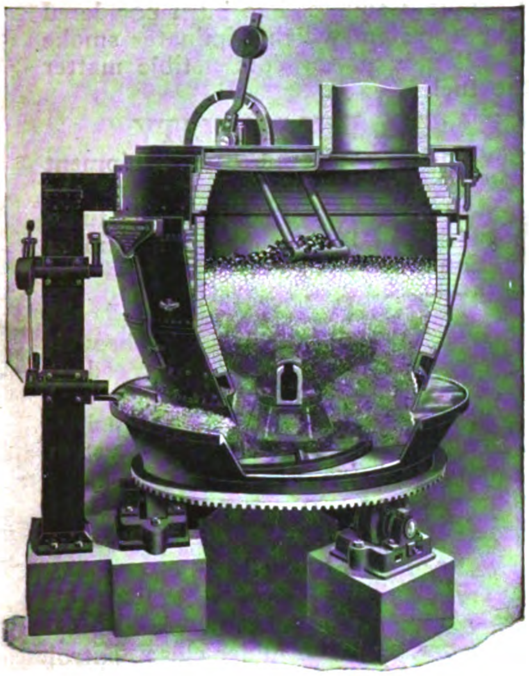
Mitsui & Co., of Japan, has purchased a 105-kw nose tilting furnace of one-ton capacity, together with a special motor operated casting table, so designed that metal may be poured directly into the moulds.

Similar equipment, but with three casting tables, has been purchased by the Parrish Pool Company of Cleveland, O.

The West Virginia Metals Corporation will install two Baily units, each of 1,500 pounds to one ton capacity. Both will be nose tilting furnaces.

The Blast Furnace and Steel Plant

Pittsburgh, March, 1920.



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